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LOCATIONAL PATTERNS OF THE CANADIAN PIG IRON INDUSTRY 1896-1926

by

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A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "Locational Patterns of the Canadian Pig Iron Industry 1896-1926," submitted by Richard J. Domokos in partial fulfilment of the requirements for the degree of Master of Arts.

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ABSTRACT

The development of the pig iron industry in Canada exhibits an interesting locational pattern. In the period 1896-1926 Ontario, a new producer, emerges in competition with Nova Scotia and in time increases its share of Canadian pig iron production. This thesis seeks to examine the reasons behind these locational developments.

Least cost location theory presents a statistical technique to analyze the initial part of the locational development, Ontario's initial establishment as a producer. To explain Ontario's increasing share over time regression analysis is used.

It was found that Ontario had an initial material cost advantage so that it could compete with Nova Scotia. Ontario's increasing share over time was explained by the pull of the local consumer market, the pull of the capital goods market and the opening of the West. The conclusions support most of the hypotheses economic historians have put forth for Ontario's predominance in pig iron production but also go beyond these explanations to an analysis of the cost positions of the producers, something economic historians have not been explicit about.

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CHAPTER I

INTRODUCTION

The Statement of the Problem

The study of the changing locational pattern of the Canadian pig iron industry in the early years of its development, 1896-1926, is both interesting and relevant for the study of Canadian economic history in general. Two questions arise out of this study that are of specific interest:

1. why Ontario began to produce pig iron at all in 1896, and

2. why Ontario achieved an increasing share of the Canadian production of pig iron over time.

Until 1896 Nova Scotia was the major producer of pig iron in Canada; Ontario having produced no pig iron since the 1840's and Quebec producing only a small amount of charcoal pig iron.

The extent of the changing locational pattern is revealed in Table 1. Ontario achieves predominance over Nova Scotia in 1897, one year after the establishment of its first successful blast furnace at Hamilton. Nova Scotia, with the establishment of the Dominion Iron and Steel Company in 1899, regained the lead producing 155,130 tons of pig iron versus Ontario's production of 116,371 in 1901.

Table 1

ANNUAL PIG IRON PRODUCTION BY PROVINCES 1896-1926

	Nova Scotia			Ontario		
Year	Tons	Value$	Share%*	Tons	Value$	Share%
1896	32,351	400,829	48.0	28,302	368,942	42.0
1897	22,500	230,000	38.7	26,115	291,466	45.0
1898	21,627	221,677	28.0	48,253	530,789	62.6
1899	31,100	404,300	30.2	64,749	808,157	62.8
1900	28,133	421,995	29.1	62,387	938,725	64.5
1901	151,130	1,764,017	55.0	116,371	1,599,413	42.4
1902	237,244	2,477,767	66.2	112,688	1,584,273	31.4
1903	201,246	2,186,273	67.5	87,004	1,345,464	29.2
1904	164,488	1,700,130	54.2	127,845	1,746,126	42.1
1905	261,014	2,440,722	49.6	256,704	3,868,197	48.8
1906	315,008	3,439,217	52.6	275,558	4,338,275	46.0
1907	366,456	4,211,913	56.2	275,459	4,581,309	42.3
1908	352,642	3,554,540	55.9	271,484	4,385,271	43.0
1909	345,380	3,453,800	45.6	407,012	6,002,441	53.8
1910	350,287	4,203,444	43.4	447,273	6,956,923	55.4
1911	390,242	4,682,904	42.5	526,635	7,606,939	57.4
1912	424,994	6,374,910	41.9	589,593	8,176,089	58.1
1913	480,068	7,201,020	42.5	648,899	9,338,992	57.5

Table 1 (continued)

	Nova Scotia			Ontario		
Year	Tons	Value$	Shares%*	Tons	Value$	Share%
1914	227,052	2,951,676	29.0	556,112	7,051,180	71.0
1915	420,275	5,463,575	46.0	493,500	5,910,624	54.0
1916	470,055	7,050,825	40.2	699,202	9,700,073	59.8
1917	472,147	10,387,234	40.8	684,642	13,902,867	59.2
1918	415,870	10,451,400	35.7	747,650	21,324,857	64.3
1919	285,087	7,141,641	31.3	624,993	17,104,151	68.7
1920	332,493	7,687,614	30.4	749,069	22,252,062	68.6
1921	169,504	4,407,104	25.4	495,489	12,882,714	74.4
1922	135,261	3,139,994	31.5	293,662	6,493,513	68.4
1923	310,972	5,360,099	31.5	674,428	15,995,496	68.4
1924	177,078	3,842,593	29.8	415,971	9,525,736	70.1
1925	226,010	4,402,674	35.3	413,248	8,040,015	64.6
1926	280,267	6,165,852	33.0	567,928	10,495,122	66.9

*% of Canadian total production in tons.

Sources - The Production of Iron and Steel in Canada 1919, Department of Mines, Mines Branch.
- Canada Yearbook, 1929.

In 1909, Ontario again became the leading producer and thereafter exhibits an increasing share of Canadian pig iron production. Figure 1 illustrates these changes graphically.

An explicit statement of the reasons why the primary iron and steel industry came to successfully establish its residence in the Province of Ontario at the expense of that province's only Canadian competitor, the Province of Nova Scotia, has never really been given. It is to this task that this thesis is devoted.

The traditional view of this problem in Canadian economic history is that the product market came to play the predominant role in the locational success of the primary pig iron producer, while the sources of supply of inputs declined in the relative strength of their locational pull. The producers of Ontario, since they were in the heart of the growing market for the products of the primary iron and steel industry, enjoyed a market advantage and thus were able to dominate Canadian primary iron and steel production including pig iron production. The Nova Scotia and Maritime's market is said to have been too small to support large scale industrial concerns because of limited population and the major Canadian market, Central Canada, too far away to allow effective competition by Maritime producers. Distance generated a transportation cost barrier that acted like a tariff.

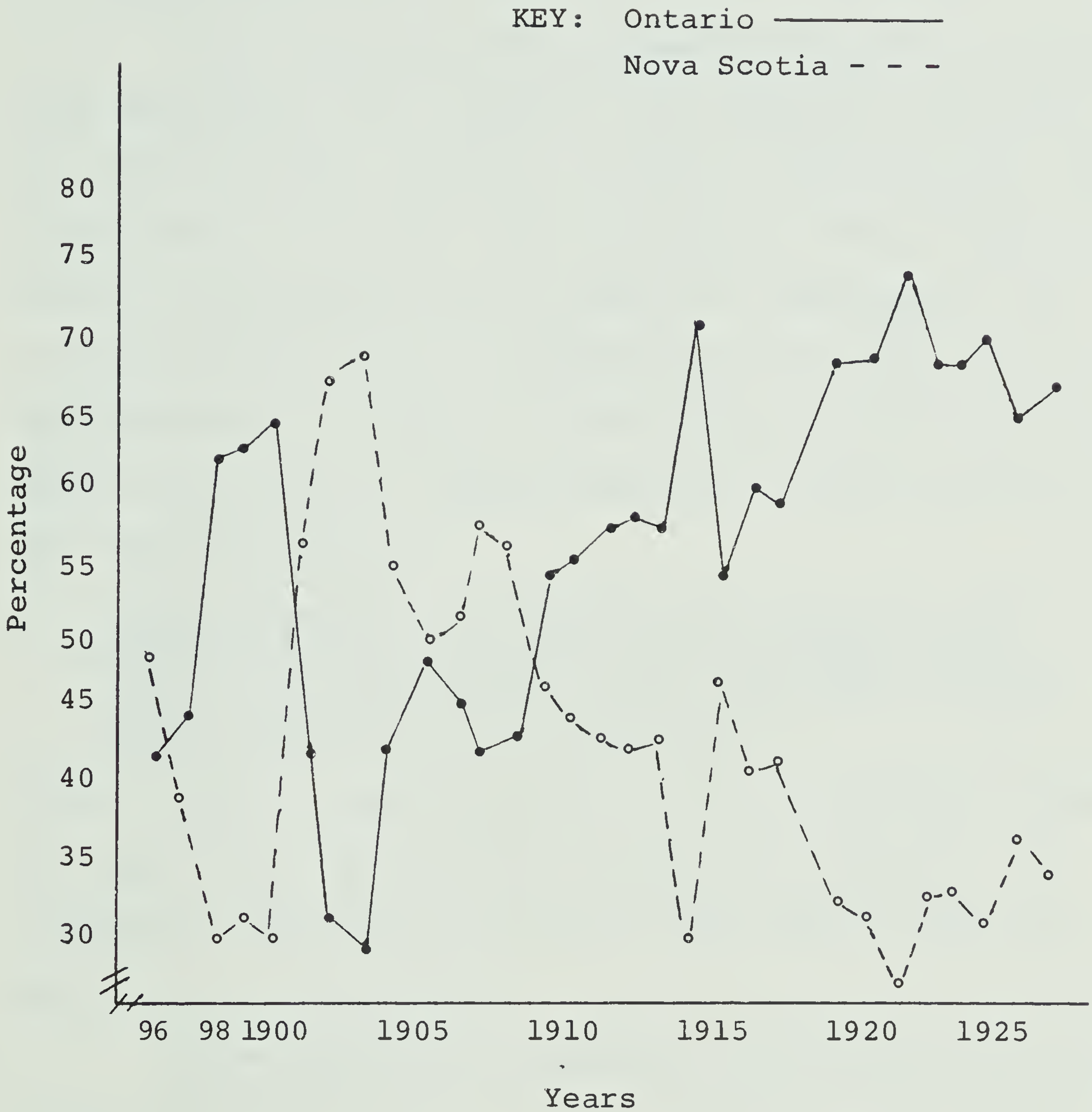

Figure 1 - Market Shares: As a percentage of Total Canadian Pig Iron Production in Tons 1896-1926.

> The sparseness of population, the difficulties of distribution within the region itself, and the cost of shipping to the interior [Central Canada], have tended to keep industries small; supplying local wants for which distance affords a natural protection, or manufacturing high quality specialty goods, the transportation costs on which are relatively insignificant.[1]

Other historians have argued in terms of the forces that determined the location of the industrial heartland of the North American continent. John B. Brebner[2] argues that, while Canadian coal and iron ore deposits, which formed the basis of nineteenth century industrial development, were located in Nova Scotia and Newfoundland away from the heavily populated central region, the coal and iron ore of the United States were found in immense quantities in this central region. He concludes that the

> immense deposits of anthracite and bituminous coal situated close to the Great Lakes waterway which leads to the very margins of the Lake Superior iron mines, forcibly drew the industrial center of North America westward from the Atlantic.[3]

Since Canada's industrialization pattern inevitably followed the lead of the United States at some time lag, her own industrial heartland was drawn to this central region as well.

These traditional arguments, attributing Ontario's

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[1] S. A. Saunders, Studies in the Economy of the Maritime Provinces (Toronto: The Macmillan Company of Canada, 1939), p. 187.

[2] North Atlantic Triangle (Toronto: McClelland and Stewart Ltd., 1966).

[3] Ibid., p. 9.

success to the pull of the market need to be tested. In addition, specific hypotheses concerning the changing shares in Ontario's favour that have been put forward without rigorous testing in Canadian economic history also need to be analyzed. What, if any, was the impact of changes in the regional distribution of population and industry as reflected by the opening of the West, the railroad construction boom, the First World War and the increasing industrialization of Canada?

Finally, the thesis intends to go beyond these explanations of the dominance of Ontario producers during this period and investigate the comparative costs of production of the two competitors in 1896 and afterwards. Perhaps the establishment and predominance of Ontario is equally explained in terms of a cost of production advantage and not a transportation advantage founded on being located at the product market. A simple reference to the role of the market is not a satisfactory explanation of the problem of the changing locational pattern of the pig iron industry.

The Scope of the Analysis

The analysis of the problem concerns the years 1896-1926, but due to statistical deficiencies it was necessary to narrow the empirical investigation to 1906-1926. The period begins in 1896 with the establishment of the first major, and in the long run, successful Ontario blast furnace at Hamilton. With a major Ontario producer in existence it

is necessary to explain its appeareance, the general development of the industry as a whole and the competition between the producers of Ontario and Nova Scotia. The analysis can be conveniently limited to 1926, for by this time the effects of the First World War and the 1920 reorganization of the Sydney based Nova Scotia producers had dissipated and a more normal state of affairs returned. Excluding these two major disruptions the competitors and their activities are seen in a normal atmosphere--one which facilitates an analysis of the long run pre-depression locational trends and an understanding of the reasons behind those trends.

The scope of the analysis, moreover, is confined to pig iron production itself within the more general classification of primary iron and steel. Of all iron and steel manufacturing activities, pig iron production has the least obvious relation to the pull of the market, because this branch of the industry is a basic primary manufacturing activity.

The Relevance of the Topic

The study of the locational pattern of the Canadian pig iron industry is important in two respects for economic history. Initially, the concern lies with explaining and understanding the development of the particular industry in and of itself. However, as no industry exists and operates in an economy in isolation, the study also has

interest because of the industry's influence in the economy as a whole. In this regard, iron and steel is especially important for it played such a vital and important role in nineteenth and early twentieth century industrialization. Thus Canada's industrial development and economic history at this time can be usefully analyzed in light of the development of her own iron and steel industry. In particular, the historical development of the pig iron industry suggests some general conclusions concerning the difficulties the Maritimes have had with respect to industrialization relative to Ontario. In this way insight can be gained into the causes of regional fragmentation with regard to industrial development in Canada.

For the Maritimes Confederation was to be the solution to their economic problems which centered on growing technological backwardness in transportation as steel and steam replaced the traditional wooden sailing ships in the carrying trade and declining export markets. The opening of the continent by the railway was to open the Central Canadian market to Maritime manufactures and products--the principal ones being products of iron and steel, fish and coal. This new market, the Maritimes envisaged, would salvage their economy from its loss of Imperial and American markets.

Their failure to realize these goals was soon apparent for most manufacturing industries, with the exception of iron and steel, failed to capitalize on the opening of the new markets, both in Central Canada and later in the

West. This failure has been a focal point in the historical and political development of this nation. The understanding of why the iron and steel industry fell prey to Central Canadian competition will facilitate a better understanding of Canada's development and perhaps yield a clearer idea of what must be done to redress the Maritime grievances that have existed since the failure of their goals from Confederation.

The Format of the Thesis

In this thesis, two techniques are used to solve the problem; the first, cost analysis, is employed to discuss the first aspect of the problem--why Ontario produces at all in 1896. The second, regression analysis, is used to test the various hypotheses concerning the changing shares of the producers--the second aspect of the problem.

In the chapter that follows a basic part of the methodology, least cost location theory, is set out. Chapter III gives a descriptive discussion of the historical development of the industry to 1926, and thereby contrasts the theoretically predicted locations with the actual developments. Chapter IV will discuss the question of why Ontario produced at all in 1896, and Chapter V is concerned with the hypotheses regarding the changing shares of production. Chapter VI draws together the results and makes some concluding remarks on the cause of the changing locational pattern of the pig iron industry.

CHAPTER II

LEAST COST LOCATION THEORY

This chapter has two general aims in presenting a discussion of location theory. Initially, the discussion will enable the prediction of the optimum location of a primary iron and steel plant given a set of locations for inputs and the market. This type of location theory, based on Alfred Weber's[1] work, however, can not be used as a basis to compare the relative success of two or more competing locations, but only to predict the optimal location of competitors.

It is necessary, then, to go beyond Weber's development of location theory to a more refined and comprehensive treatment such as E. Hoover's.[2] The least cost theory extensions he develops enables the comparison of the respective competing locations with respect to any components of cost that are deemed to be essential to a particular industry study.

Alfred Weber's Theory of Location

The least cost orientation of location theory owes

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[1] Alfred Weber's Theory of the Location of Industries, trans. C. J. Friedrich (Chicago: University of Chicago Press, 1929).

[2] The Location of Economic Activity (New York: MacGraw-Hill Book Company, 1948).

its beginning to Alfred Weber, whose prime interest was to discover those forces which influence the location of industrial activity and thus to formulate a pure theory of industrial location applicable to all times. These forces which operate as the economic determinants of a firm's location are called location factors, being specified in terms of a saving of cost, either production or distribution costs, which is obtained when a firm locates in one locale rather than another. In order to keep this theory universally applicable to all industrial activity, he disregarded those special location factors that arise from the technical or geographical nature of the production process such as

> the perishability of raw materials, the influence of the degree of humidity of the air upon the manufacturing process, the dependence upon fresh water etc. . . .[3]

and thus affect particular industries only. Moreover, he disregarded social and cultural factors so that only a pure theory of economic location remains.

Upon examining the industrial process of production and distribution, Weber isolated three general factors that determine the location of a firm in any economic system;

> the relative price range of deposits of materials, the costs of labor and transportation, then, are the regional factors of the location of every industry.[4]

He then assumed away differentials in the first factor by

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[3] Weber, p. 20.

[4] *Ibid.*, p. 34.

proposing to express differences in the prices of various deposits of materials in terms of differences in transportation costs so that all that remains as factors are transportation and labor costs.

Weber's major assumptions that have relevance for this present work are as follows: the sources of raw materials and the places of consumption are all geographically given. With respect to demand, he assumed that a firm faces a perfectly elastic demand curve. With respect to transportation, the rates are uniform for the same quality of material throughout the country and are directly proportional to distance. And finally, the cost of materials is equal at all deposits. This last assumption seems unnecessary if he can legitimately express material cost differentials in terms of transportation costs. As it is, he has this method in mind, but proceeds as if material costs are the same at all deposits.

In his treatise, Weber placed prime importance on transportation costs so that industry, in the first instance, is drawn to locate at the point of lowest costs of transportation with respect to the places of consumption and the sources of materials. However, labor cost savings, if they are substantial in a location that is not at the spot of minimum transportation costs, can outweigh the transportation cost factor. The savings in labor cost must be greater than the increase in the transportation burden incurred by not

locating at the minimum transportation cost location.

His method, then, is a combination of substitution of two locational factors, labor and transportation cost, and of partial equilibrium analysis which enables him to solve the locational problem by minimizing transportation costs (not withstanding alterations of location labor costs may induce) given demand and equal production costs at various potential locations.

The exact location of the industry can be narrowed down beyond the general position of minimum transportation cost. Weber introduced, in order to solve this problem of optimal location, the concept of a locational figure constructed by the connection of the points of consumption (Weber usually assumed one) and the sources of material. The optimal location is determined by the interaction of the various forces which tend to draw the location either towards a source of raw material or a place of consumption.

Weber expressed the various forces in terms of the respective weights per ton mile of the inputs and of the final product. The relative strength of a force that exerts a locational pull is represented by the size of its respective weight per ton mile.

In order to understand what determines the relative strength of the respective weight, the characteristics of the material used need to be established. Weber classified these materials into two categories:

1. by the nature of their deposits, and
2. by the nature of their transformation into finished or semi-finished products.

In the first category he defined two types of deposits: the first ubiquities, those deposits of a particular material that are, for all intents and purposes, found everywhere by nature; the second, localized materials not being so readily available as ubiquities, are found only in geographically well defined places. Weber discussed further the character of this classification of materials;

> it is obvious that it is not predetermined for all time whether an industrial material is "localized" or "ubiquitous"; this must be determined within each area, country or region for the period which is made the object of locational analysis.[5]

In the second category which is of more importance to locational analysis than the first, he defined two types of materials on the basis of their weight transformation properties in the production process. The first, the pure material, passes on its entire weight to the product during the production process. The second, the gross or weight-losing material, passes on some fraction of its weight to the product in the production process.

By the use of these classifications he devised a method of predicting to which corner of the locational figure location tends to gravitate. Weber described this method:

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[5]Weber, p. 52.

> the determining factor is not the proportion of the weight of used material to the weight of the product, but the proportion of the weight of used localized materials to the weight of the product, all ubiquities being of importance only as they increase this weight of the product. This proportion of weight of localized material to weight of product we shall term "material index" of production.[6]

All industries, for example, whose material index is not greater than one locate at the place of consumption since less transportation costs are incurred by moving the localized materials than the final product. Weber's analysis, it should be recalled, does not allow for any politically discriminatory rate structures. That is, it costs the same per ton mile to ship the raw material in any direction as it does the final product, barring any differences in the nature of product such as fragility or perishability.

Pure materials, then, because of minimum transportation cost considerations will never bind the place of location of the firm to the source of their deposits. Weight-losing materials will pull production to their deposits but if there are several geographically dispersed deposits no precise location can be given. If weight-losing materials are used in conjunction with pure materials the pull of the weight-losing materials is lessened but the location of the plant can never be at the place of consumption unless its component is strengthened by the weight of ubiquities.

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[6] Ibid., p. 60.

Although Weber concentrates on and acts as if the cost of transportation were the only really significant factor he did realize that labor costs can not be ignored, for real wages and productivity will seldom be equalized regionally by labor mobility. Indeed the lack of mobility requires the consideration of labor in most locational analysis wherein it is often the case that labor costs are the decisive factor outweighing the least cost transportation orientation.

Hoover's Extension of Least Cost Location Theory

Hoover's analysis of the locational decision follows directly from Weber's but it is more refined and comprehensive. He divides the costs that are likely to influence the locational decision into two major categories, processing costs and distribution costs. He maintains an argument similar to Weber's with respect to location when distribution cost factors dominate.

He is, however, more comprehensive in his concern for the components of processing costs. These costs are determined by the prices of the respective factors when factor prices change. Besides a consideration of labor cost similar to Weber's, he makes possible the consideration of other factors of production and their costs, such as capital, rent and raw material, and other components of cost such as insurance and taxes, if deemed necessary, in the locational analysis of an industry.

For Hoover, then

> the locational problem is again a problem of substitution among costs, now production cost and transportation cost, the ultimate objective being the minimization of these expenses.[7]

By comparing average per unit costs with respect to certain cost components deemed significant to a particular industry, it is possible to compare the locational cost advantage one firm might have over another. This advantage will determine the success of one firm and the relative failure of another.

The Locational Orientation of the Iron and Steel Industry

With these general theoretical remarks outlined, it is now possible to say something about the locational orientation of the primary iron and steel industry itself. Moreover, a prediction as to the likely location of the primary iron and steel plant can be made.

The principal materials used in the production of pig iron are coke, made from coal, and iron ore. Secondary materials used are scrap and limestone. Into the furnace alternate layers of iron ore, coke and limestone are charged.[8] Once the hot air blast is blown into the furnace, the iron ore is exposed to the reducing action of carbon monoxide gas

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[7] M. L. Greenhut, Plant Location: In Theory and Practice (Chapel Hill: The University of North Carolina Press, 1956), p. 21.

[8] This description of the pig iron production process is based on Lucy Morgan's Appendix to her book The Canadian Primary Iron and Steel Industry (Ottawa: Queen's Printer, 1956).

which is produced by the burning of the fuel. This chemical reaction releases the iron from the ore and another reaction creates a slag by the reaction of the limestone with impurities in the coke and iron ore. The molten iron can then be drawn off, cast into pigs and sold or be transferred to the steel furnaces depending on the degree of integration of the firm.

The reasons for the desirability of integration of iron and steel works from the blast furnace to the steel furnace and to the rolling mills are obvious. In order to conserve fuel and minimize fuel costs, iron is handled in its molten state in its conversion to steel rather than being cast exclusively into pigs, sold and then reheated by independent steel producers.

This is not to say that integration of the blast furnace and other secondary stages of the iron and steel industry is always necessary or even profitable. It can be the case in which a steel producer, necessarily located at the market because his material inputs are generally pure materials, will not operate a blast furnace but rather use purchased pig iron. He will operate a furnace if, for example, he can bring together ore and coal or coke and produce pig iron at a competitive cost as may be bought on the market. But if cost considerations are not such, a pig iron producer, not located at the market, but at the source of materials will be able to supply pig iron to the steel

producer. The existence of non-integrated blast furnaces and steel furnaces supports the view that integration is not necessary.

From this brief description of the pig iron production process, the characteristics of the materials used are revealed; both the fuel and ore are weight-losing, the former contributing a very small portion of carbon to the iron, about 2 per cent in the case of cast iron. The iron ore, on the other hand, contributes a much larger proportion of its weight to the final product--the exact proportion depending on the iron content of the ore. A typical range of iron content in ore can be from 30 per cent to 70 per cent. In general,

> the relative weight of ore and coal [coke] required vary according to the richness of the ore, the heat value of the coal, the technology used, and the availability of scrap to supplement the ore charged.[9]

With these characteristics in mind, location theory can now predict the point of location of a blast furnace operation. With the sources of iron ore and coal for coking and the market geographically separated, location will generally be drawn to the sources of materials because of the weight-losing nature of these materials and the firm's desire to minimize transportation costs. Moreover, the material which loses the most absolute weight exhibits the greater attracting force. For the iron and steel industry,

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[9]Hoover, p. 43.

since the coal input has generally lost more weight in the production process, coal deposits have exerted the predominant locational pull even though in absolute terms the quantities of coke used may not always exceed the quantities of ore used per ton of output.

However, as Isard's[10] thesis suggests, this may not be exclusively the case over the nineteenth and twentieth centuries. Over time, a reduction in the quantities of coal required for coking purposes per ton of pig iron has been occurring due to technological change, while iron ore requirements per ton have remained roughly the same. In presenting data for Great Britain and the United States, he concludes that

> in contrast to the market decline in consumption of coal per ton of pig iron, there has been a relatively constant consumption of iron ore.[11]

Thus the coal site is losing its relative weight which determines its locational pull. Other sources of supply of materials or even the market may now enter as the predominant locational force.

If Isard's thesis does hold up, a major locational readjustment has been occurring in the iron and steel industry which has been reducing the locational pull of the coal site by reducing quantities required for the production

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[10] W. Isard, "Some Locational Factors in the Iron and Steel Industry Since the Early Nineteenth Century." In Journal of Political Economy, 56 (June, 1949), pp. 203-217.

[11] Ibid., p. 205.

process. If this is the case, the prediction of location at a coal site might not be completely warranted.

The reasons for limiting the scope of the analysis to blast furnace operations are now apparent. Because the later stages of the primary iron and steel industry begin to use pure materials that do not lose weight in the production process as inputs, their location is determined in the main by the location of the market for its product. Thus Ontario's relative success and Nova Scotia's failure in securing these later stages is not surprising since the main and growing market for iron and steel products was the industrial heartland of Canada, Ontario and Quebec.

The locational anomaly lies in the blast furnace sphere of the industry because of its materials' weight-losing characteristics. It is not so clear why Ontario, a market location, succeeded and in fact, it is necessary to begin with the question of why Ontario even began producing pig iron in light of its resource endowments. It is also not so clear why Nova Scotia, a resource location, was unable to dominate pig iron production by supplying Central Canadian steel producers, considering its resource endowments.

CHAPTER III

THE CANADIAN EXPERIENCE[1]

Resource and Market Locations

Since iron ore and coal are the two major resource inputs in the pig iron production process, this chapter looks at the distribution of these resources in Canada. With the location of these inputs determined, the theory discussed in Chapter II can be used to interpret the feasible Canadian locations and to analyze the historical development of the industry.

Nova Scotia possessed local deposits of iron ore, but not adequate high grade quantities to be self-sufficient. The Department of Mines, in 1908, reported that:

> the iron ores of Nova Scotia are not confined to any particular geographical horizon. In fifteen out of eighteen counties of the Province, iron ore of more or less extent has been found. Many of these discoveries are just sufficient to tempt, but not to reward exploitation, others are found to be valuable.[2]

Deposits existed at Clementsport, Nictaux Falls, in Londonderry, Colchester and Cumberland counties. Less promising deposits existed elsewhere. Donald came to the

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[1]The material in this chapter relies heavily on the work of W. J. A. Donald, The Canadian Iron and Steel Industry (Boston: The Riverside Press, 1915), and W. Kilbourn, The Elements Combined (Toronto: Clarke, Irwin and Company, 1960).

[2]Department of Mines, Mines Branch, Report on the Mining and Metallurgical Industry of Canada, 1907-1908 (Ottawa: Government Printing Bureau, 1908), p. 253.

conclusion that Nova Scotia's ore deposits were economic only if they were used to complement other sources of supply for any significant deposits were of low grade.

Nova Scotia has had, therefore, to depend on iron ore supplies from the Wabana Mine on Belle Isle, Newfoundland. With regards to the ore's characteristics and merits, Donald suggested that,

> while it is not so rich as the Lake Superior ores, yet it is of fair grade. It mixes readily with other ores, and its ease of mining, its abundance, accessibility and cheapness of transport almost neutralize its slight shortage in mineral.[3]

With regard to coal, Nova Scotia was endowed with numerous fields. On the mainland, Pictou and Cumberland counties were the chief coal areas; the former covering 50 square miles, the latter 350 square miles. A third significant field of 125 square miles existed on Cape Breton near Sydney. Donald concluded from this:

> Nova Scotia, then, has practically inexhaustible supplies of coal, most of which may be used for making coke and favourably located for use with imported ores.[4]

In general, Nova Scotia's resource position was quite favourable for the production of pig iron. Major coal deposits were located on the coast so that iron ore could be cheaply shipped to the plant and the product could be cheaply shipped to the market. Thus, Nova Scotia, using

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[3] W. J. A. Donald, The Canadian Iron and Steel Industry (Boston: The Riverside Press, 1915), p. 25.

[4] Ibid., p. 29.

Newfoundland ore and her own coal, with a transportation advantage with respect to these inputs, could at this stage expect an iron and steel industry.

With regard to the endowment of resources in Ontario, the same Department of Mines report stated:

> although a number of locations of ore have been made in various sections of the Province, some being extensive ore bodies, actual mining has been carried on in but a few instances.[5]

However, the quantities of ore exploited from the Helen, Josephine, and Magpie Mines in the Michipicoten districts far exceeded the Nova Scotian output; see Table 2. Other potential deposits at this time were economically inaccessible because of the lack of adequate transportation facilities. The other major potential source of iron ore for Ontario producers was the Mesabi Range near Lake Superior, from which high grade ore could be economically shipped to blast furnaces located on the Great Lakes.

Ontario's complete lack of coal as a fuel was the most obvious stumbling block to successful pig iron production. A producer had either to import coal for coking, or coke itself, from Nova Scotia or from the Pennsylvania coal fields in the United States. The Pennsylvania coal fields were a potential source for coal or coke since a shorter shipping distance via the Welland Canal was involved than for coal or coke coming from Nova Scotia via the St. Lawrence

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[5] Department of Mines, Mines Branch, op. cit., p. 315.

Table 2

SHIPMENTS OF IRON ORE IN TONS FROM CANADIAN MINES 1896-1926

Year	Nova Scotia	Ontario
1896	58,810	15,270
1897	23,400	2,770
1898	19,079	21,111
1899	28,000	25,126
1900	18,940	82,950
1901	18,619	272,538
1902	16,172	359,288
1903	40,335	209,634
1904	61,293	141,601
1905	84,952	193,464
1906	97,820	141,078
1907	89,839	207,769
1908	11,802	216,177
1909	- -	263,893
1910	18,134	231,445
1911	22	175,586
1912	30,857	112,321
1913	20,436	195,680
1914	- -	240,680
1915	- -	394,429
1916	- -	271,967
1917	- -	198,152
1918	130	201,119
1919	- -	195,649
1920	- -	126,912
1921	- -	58,499
1922	- -	16,190
1923	- -	30,447
1924	- -	44
1925	- -	- -
1926	- -	- -

Source - Annual Report of the Mineral Production of Canada, 1926, Department of Mines, Mines Branch.

River.

In Canada, the main market for pig iron during this period of time was primarily Ontario and secondarily Quebec. This is reflected by the data in Table 3. Ontario had an enormous lead both in the number of iron and steel concerns which were using pig iron as an input and in the value of the output produced or size of the concerns. This of course reflects the preeminence of this region as the industrial heartland of the country. It can safely be assumed that the major market advantage would lie with an Ontario location.

Other areas of Canada at this time had little to offer the pig iron producer either in terms of resources or in terms of markets. Quebec had the best claim by virtue of its secondary position as a market location although it had little iron ore except bog ore and no coal. It was not in a position to import iron ore or coal cheaply enough to compete with either the Ontario or Nova Scotia blast furnace operators.

With this description of markets and sources of materials it is now possible to analyze Canadian locations for blast furnace operations. From a pure location theory point of view Nova Scotia, especially Sydney, was a logical location because of its coal sites and the easy accessibility of ore. With Isard's[6] thesis in mind, Hamilton appears as the most feasible Ontario location because of its

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[6] Isard, <u>op. cit</u>. See discussion <u>infra</u> p. 21.

Table 3

IRON AND STEEL CONSUMERS BY PROVINCE IN SELECTED YEARS

Year	Ontario		Nova Scotia		Quebec	
	Estab-lishments	Value of Products$	Estab-lishments	Value of Products$	Estab-lishments	Value of Products$
1901*	13	1,854,940	--	- - - - -	10	3,455,578
1910*	58	22,024,705	5	3,896,185	12	5,256,597
1922	645	248,696,521	35	11,840,370	203	55,511,456
1923	643	325,355,757	36	24,662,553	180	97,485,897
1924	645	265,020,580	36	13,522,833	174	75,759,038
1925	672	290,434,900	35	11,658,621	195	77,394,080
1926	698	354,167,335	33	14,460,837	215	99,303,655

*The classification of industries is not comparable for 1901-1910 versus 1922-1926.

Sources - Census of Canada 1901, 1910.
- Iron and Steel and Their Products, 1926, Dominion Bureau of Statistics.

geographical position. Although apparently not a primary resource site, it was a convenient assembly point for raw materials and was favourably located near the main pig iron market.

The Early Trials of the Canadian Iron Industry (1730-1896)

The first recorded attempt to smelt iron was at St. Maurice Forges, Three Rivers, Quebec in 1730. Ontario and Nova Scotia had their premier attempts at later dates; 1800 at Lyndhurst for the former and 1825 at Clementsport for the latter.

The only partial successes in this period were at Normandale, Ontario and Londonderry, Nova Scotia. The Normandale furnace was in blast from 1815 to 1847 supplying manufactured articles for customers in and around Lake Ontario and Lake Erie, but was closed when the fuel and ore of the neighborhood were exhausted.

The Londonderry enterprise was a more elaborate attempt. The plant, which included a coke blast furnace and later a Siemens open-hearth steel furnace and extensive finishing mills, operated from 1850 to 1879. In 1873, the company was reorganized under the chairmanship of Dr. Siemens in order to manufacture steel directly from iron ore by the Siemens open-hearth process. As all the pioneers before it, the company ran into difficulties and was liquidated by 1885.

These and other early attempts at successful

smelting were generally short-lived. Several technical factors hampered the early developments before 1896, such as the lack of adequate ores of sufficient quality and quantity for a permanent industry. Inexperienced workmen and inadequate management spelt the doom of several firms. The charcoal fuel used at this time produced the highest quality pig iron but depended on the extent of the surrounding hardwood forests. Once the forest was exhausted the fuel supply was gone as well.

The lack of transportation facilities, shortages of capital and the lack of an adequate market, either domestic or foreign, did little to ensure the success of the first feeble attempts to produce pig iron. One observer placed the emphasis in this way:

> the indifferent success of the early ventures in the manufacture of iron was due to several factors, including the supply and character of the ores and fuel and the nature and extent of the market.[7]

Beginnings of the Twentieth Century Iron and Steel Industry

Only one firm in existence prior to 1896 managed to play a prominent role in the rapid expansion of the Canadian primary iron and steel industry after this date--the Nova Scotia Forge Company. The company opened in 1872 as a small forging plant but grew steadily until 1882 when a steel concern was opened to supply the forge with raw material.

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[7]Dominion Bureau of Statistics, The Production of Iron and Steel and Their Products (Ottawa: King's Printer, 1925), p. 10.

The companies merged together in 1889 to form the Nova Scotia Steel and Forge Company. Six years later, in order to remove dependence on imported pig iron as a raw material for the steel furnace, their company united with the New Glasgow Iron, Coal and Railway Company which operated a blast furnace at Ferrona, Nova Scotia to form the Nova Scotia Steel Company. In 1895 they acquired the Belle Isle deposits as a source of iron ore.

In 1901, the Nova Scotia Steel and Coal Company was formed to acquire the steel company plus the mining properties of the General Mining Association at Sydney Mines and thus provide a secure supply of coal for the furnaces. The location of the blast furnace was moved from Ferrona to Sydney Mines in 1904 in order to shorten the distance of shipping ore from the Wabana Mine. Additions made to the facilities included two rolling mills, three steel furnaces and 150 coke ovens. In 1910, the blast and open-hearth steel furnaces were remodeled, while in 1912 the company formed the Eastern Car Company to build steel railway cars near the steel plant.

Donald, in his comments on this firm's progress had nothing but praise:

> the machinery is of the most modern character. Coal washers, coke ovens, coal and ore piers at North Sydney and Wabana, the railway connecting North Sydney with various plants at Sydney Mines, steel furnaces, repair shop and foundries, dwelling houses and stores at

> Sydney Mines complete a most efficient plant for the production of pig iron and steel billets.[8]

As regards profitability he notes that "the success of the Nova Scotia Steel and Coal Company is a byword in Canadian finance."[9]

The history of the other major Nova Scotia pig iron producer, the Dominion Iron and Steel Company, reveals a growth pattern as spectacular as the Nova Scotia Steel and Coal Company but much more fluctuating. The works was established in 1899 when a Boston financier and capitalist established an iron and steel plant at Sydney to utilize the output of the Dominion Coal Company, an allied firm. In 1900, the building of four blast furnaces with varying capacity of 250 to 400 tons of pig iron per day, 10 basic open-hearth steel furnaces, a blooming mill and 400 coke ovens was begun. A wire mill was opened in 1904 and a rail mill in 1905.

In order to settle a long standing dispute over the supply of coal with the Dominion Coal Company, the two firms amalgamated in 1910 to form the Dominion Steel Corporation. The main benefit of this arrangement was that a secure supply of coal was assured for the iron and steel branches.

When threats of the elimination of tariffs and bounties on iron and steel products seemed imminent, the

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[8] Donald, p. 198.

[9] _Ibid._, p. 199.

firm expanded capacity hoping that increased efficiency from economies of scale would counteract any adverse effects that the moves by the government would have. By 1913, the future of the Dominion Steel Corporation seemed bright.

With the establishment, then, of these two major producers, the Dominion Steel Corporation and the Nova Scotia Steel and Coal Company, with similar production aims a further amalgamation was logical. This was accomplished by the reorganization of the two companies by a group of British and American capitalists in 1920. The new company became the British Empire Steel Corporation. The company was reorganized again in 1928 under Canadian owners and given its name, the Dominion Steel and Coal Corporation which lasted until the 1960's.

The province of Ontario had no iron and steel concerns bridging the gap between the early trials and the later successes as did the Nova Scotia Forge Company. In fact, as Kilbourn notes:

> there had been no steady supply of basic iron in Ontario since the little charcoal furnace at Normandale, Lake Erie, exhausted the ore supply of its surrounding bog and was abandoned in 1850.[10]

In response to bounties and tariffs that were continually placed on pig iron since 1879 to induce basic pig iron production in Canada, a group of American capitalists came looking for a suitable location for an iron and

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[10] W. Kilbourn, The Elements Combined (Toronto: Clarke, Irwin and Company, 1960), p. 47.

steel works in Ontario. An offer, made by the city of Hamilton, was accepted by them in 1893. The terms of the offer included a free site, long term tax exemptions and bonuses totaling $100,000. In return the group agreed to construct a $400,000 blast furnace and a $400,000 open-hearth steel furnace. Thus was formed the Hamilton Blast Furnace Company.

The 200 ton blast furnace was erected in 1895 and was in blast the following year, giving the province its first domestic source of pig iron for over forty years. A steel plant, spike factory, and a puddling furnace were added two years later. A prospective major inducement, bonuses for the use of Ontario ore, never proved worthwhile to this firm. The southern Ontario ores caused smelting problems and Lake Superior ores were used instead.

In 1899, the blast furnace company amalgamated with the Ontario Rolling Mills Company as the Hamilton Iron and Steel Company, with the intention that the finishing plant would serve as an outlet for the less finished product of the other plant. Two steel furnaces were purchased and the first open-hearth steel was poured in 1900.

The plant expanded slowly adding capacity in the rolling and finishing mills, giving it a much broader product basis than its Nova Scotia and Ontario competitors. The major development for the company was the addition in 1907 of a 250 ton blast furnace.

The company achieved an even greater degree of

integration and diversification of product lines when in 1910 an amalgamation of the Hamilton Iron and Steel Company, Montreal Rolling Mills Company, the Canada Screw Company, the Dominion Wire Manufacturing Company, and the Canada Bolt and Nut Company was made under the name of the Steel Company of Canada. Additional equipment was added in 1911 and 1912 including a blooming mill, a rod and bar mill and two more 50 ton open-hearth steel furnaces. By this time the Steel Company of Canada had a modern and well equipped iron and steel concern with product diversification running the gamut from pig iron and open-hearth steel to semi and fully finished products. It was a well diversified iron and steel concern destined to become Canada's largest.

In April 1901, the Algoma Steel Company was formed as a subsidiary of the Consolidated Lake Superior Company, which was formed in 1899 to develop industry at Sault Ste. Marie, after the promoter F. H. Clerque had persuaded the Canadian government to make mandatory use of Canadian made rails a condition to all future railway subsidies, and to buy a large quantity of his company's rails. The $10,000,000 plant was to include two charcoal furnaces which were subsequently left incomplete, two coke blast furnaces, a coke plant, a Bessemer steel mill, a blooming mill and a rail mill. Steel rails were rolled in May 1902 but the works was closed because of a series of misfortunes and difficulties.

The firm met with adverse price competition with respect to its rail contract with the government. Because of its inability to secure pig iron, its own furnaces not being finished, it lost out on other rail contracts. Matters were complicated by the firm's inability to repay a loan and the firm was closed in 1903. The company returned to life in 1905 after a reorganization of its financial affairs.

The company soon began expansion of its operations because of increases in its railway business. The first major step was the conversion from Bessemer to open-hearth steel furnaces which allowed the use of higher phosphorous content Canadian ores in making pig iron. New coke ovens, blast furnaces and steel furnaces were built to keep the finishing mills supplied with raw materials. Further expansion continued after the company switched to British and Canadian owners. Other finishing mills were added including a new rail mill and a 500 ton per day blast furnace in 1911. Additional open-hearth steel furnaces and a merchant mill for the production of heavy structural steel were completed in 1914.

By this time Algoma was one of Canada's leading iron and steel producing companies supplying steel rails to most of the major railroads in Canada and the United States. It ranked second to the Dominion Iron and Steel Corporation in terms of its capacity to produce pig iron, 1160 tons per day as compared to 1600 tons per day.

Besides these two giants in the Ontario iron and steel industry, several lesser companies were engaged in the production of pig iron. The Canadian Iron Furnace Company at Midland, Ontario with a furnace capacity that was once as high as 415 tons per day experienced financial difficulty, was forced into insolvency and was finally absorbed into the Algoma Steel Company in 1917 which moved the main furnace to its site in Sault Ste. Marie. The Deseronto Iron Company formed in 1898 to build a blast furnace to manufacture charcoal pig iron ran into difficulties obtaining wood. The furnace was later purchased by the Standard Iron Company which also operated a small furnace at Parry Sound, Ontario. By 1926, however, both furnaces had been idle for several years. The Canadian Furnace Company erected a comparatively large blast furnace at Port Colbourne on Lake Erie with a capacity of 350 tons per day in 1913. The company was forced to cease operation and the furnace has been out of blast since November, 1924.

At the end of 1926 only three companies maintained blast furnace operations, all in conjunction with their integrated works. The Algoma Steel Company had furnaces with a total rated capacity of 1600 tons per day, the Steel Company of Canada 825 tons per day and the British Empire Steel Corporation 1400 tons per day.

Post 1913 Developments

The most exciting decade for these new iron and

steel concerns was 1910-1920 after they had placed into position the foundations for their future development. The expansion of the firms in the previous decade of the wheat boom was halted by a serious recession in 1913. The recession hit heavy industry hard and iron and steel orders during the winter of 1913-1914 fell off drastically. Just as recovery seemed imminent in the spring of 1914, the Canadian economy was thrown into chaos as a result of the declaration of the First World War.

In general, the steel companies hovered close to bankruptcy as railway, hardware and agricultural implement business was non-existent. For most Canadian industry the beginning of the war spelt unused capacity and high levels of unemployment.

The war altered this situation as Britain turned to North America for food, supplies and ammunition. Once certain technical problems were solved regarding the quality of Canadian steel, Canadian producers were able to turn the war into the most profitable venture the companies had experienced. Besides direct stimulation from war-time steel demand, the industry was faced with a general revival of the economy. European food shortages had caused wheat prices to soar which led to railway and farm equipment demands on the industry's output and capacity.

Some economic historians have postulated that this war had caused a shift of Canada's heartland back to the

Atlantic provinces, a position which the Maritimes had lost since the mid-nineteenth century. B. S. Keirstead and M. S. Keirstead had this comment to make on the Maritime economy:

> during the Great War of 1914-1918 it [heavy steel industry] met the need for steam coal for warships and merchant-men making up the convoys in Halifax, and for heavy steel used in shipbuilding and armaments. . . . with the outbreak of the present war resumed their historic role as prime provider of the sinews of war.[11]

Whether this is so remains to be tested. From the data on pig iron production it seems that Nova Scotia gained in her share in but only one year, 1915, before slipping back to her declining role.

Although the war had generally benefited the iron and steel industry, the post-war years were a period of careful reorganization and reorientation, especially in the light of the excess capacity that the industry had built up. The 1921 recession was to have adverse effects, especially on the Algoma Steel Company and the newly reorganized British Empire Steel Corporation. Moreover, these two firms had difficulty in obtaining capital for the diversification of their product lines to meet the changing needs of Canadian steel users in the 1920's. The Steel Company of Canada, on the other hand, was particularly well equipped to handle the growing demand for a wide variety of finished steel products

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[11] B. S. Keirstead and M. S. Keirstead, The Impact of the War on the Maritime Economy (Halifax: Imperial Publishing Company, 1944), p. 4.

that the consumer sector of the economy was demanding. Until the depression the Steel Company of Canada was the most successful iron and steel concern in the country.

Illustration 1

CHAPTER IV

COST ANALYSIS

Theoretical Interpretation of the History

An interpretation of the history of the iron and steel industry in Canada can be given in terms of location theory and Isard's thesis concerning the changing locational pattern of the industry in the nineteenth century. Prior to 1896, the location of successful pig iron producers in Canada was determined by traditional locational forces. Nova Scotia, because of its endowments of coal and accessibility to iron ore, dominated Canadian pig iron production. Ontario, because of its lack of coal the prime weight-losing material, was unable to establish a successful producer until this time.

Economic historians have implicitly used this thesis to explain the appearance of a successful Ontario iron and steel producer. Since coal sites were losing the strength of their locational pull because of technical advances and savings in the use of coke as a fuel, Ontario, a market orientated location, could become a pig iron producer. For Ontario, as the amount of coke required to produce a ton of pig iron declined, the cost disadvantage associated with not producing at a coal site would be lessened.

If it is granted that Isard's thesis holds for Canada as well as the United States and Great Britain, a

major reorientation of the locational pattern of the iron and steel industry was occurring. The possibility for Ontario, a market location, to achieve a pig iron producer increased as the coal site lost its locational pull. However, Isard's thesis can not be used to explain why Ontario actually succeeded in 1896 as a producer in competition with Nova Scotia. The rest of this chapter will examine the material costs of the production process in order to determine why Ontario was able to produce pig iron in light of competition from the Nova Scotia producers. In this respect, there is no a priori reason to believe one producer had an advantage over the other since different sources of materials were used.

Components of Cost to be Examined

Hoover, as earlier noted, set out a variety of general costs that might vary as to locations and thus be important for a successful location; capital, labor, material, land and institutional costs. Not all of these will be as equally important for every industry and at every point of time.

Since capital had to be raised in the same money markets by the producers of Nova Scotia and Ontario, no significant differences in capital costs should have occurred that would have yielded a producer a long term locational advantage. Thus it is not necessary that capital costs be included in the analysis.

The same is not necessarily the case for labor which is generally less mobile than capital. Differences in labor costs as represented by wages and salaries might be an important element in the successful location of the pig iron producer.

Material costs, if the producers were not using the same sources of supply, might also be expected to differ regionally and thus be an important part of the success of a location. As has been seen, the producers of Nova Scotia and Ontario used different sources of supply. It can be expected that, since iron ore and coke are the major material inputs, variations in the prices and qualities of these inputs contribute to the relative competitiveness of the respective producers, and thus form an integral part of the cost analysis.

The last two cost elements, land and institutional costs such as insurance and taxes, can be dispensed with in the analysis for in a majority of cases free sites were given to the producers and long term tax exemptions acquired. Thus there are probably no regional differences involved that might contribute to successful location.

Of these components of production cost, the analysis will be confined to the materials cost with respect to iron ore and coke. It is these elements that might vary regionally and thus are very important to the success of a particular location. Unfortunately, no direct employment

data is available to facilitate the analysis of labor cost here, but a proxy is included in the regression analysis in Chapter V.

The Data

As with most theses in economic history that attempt to deal with a topic from an empirical point of view as well as a descriptive one, the problem of data deficiencies plays a prominent role. In fact, the construction of variables and data series, previously neglected, must occupy a large part of a researcher's time.

The first major difficulty encountered was the lack of data at the provincial level on the quantities and prices of the inputs used in the pig iron industry. The first task, then, was to derive these series from existing national data. Knowledge of the history of the iron and steel industry provided the rationale for the particular method of disaggregation used. The Canadian data is presented in Table 4, while the derived provincial data appears in Table 5.

The information essential to the exercise is this comment on the sources of the inputs:

> the iron industry at Sydney and North Sydney have been built up on the basis of the Newfoundland Wabana ores and the local coal supply. . . . In Ontario large quantities of United States "Lake Ores" are used, the imported ores charged being 623,094 tons and the

Table 4

MATERIALS CHARGED TO BLAST FURNACES IN CANADA
1906-1926 (Short Tons)

Year	Iron Ore Imported	Iron Ore Domestic	Coke Made From Domestic Coal	Coke Imported or Made From Imported Coal
1906	- - -	- - - -	462,672	327,082
1907	- - -	- - - -	521,068	304,676
1908	1,051,445	209,266	492,076	325,670
1909	1,235,000	231,994	412,016	507,255
1910	1,377,035	149,505	491,281	476,838
1911	1,628,368	67,434	543,933	577,388
1912	2,019,165	71,588	609,183	656,815
1913	2,110,828	139,436	710,260	706,888
1914	1,324,326	182,964	330,269	590,902
1915	1,463,488	293,305	578,743	486,022
1916	1,964,598	221,773	712,715	645,488
1917	2,084,231	92,065	634,962	723,657
1918	2,146,995	96,745	561,135	861,522
1919	1,674,194	78,391	372,203	689,548
1920	1,957,738	149,180	415,742	788,795
1921	1,141,007	126,653	244,830	526,963
1922	788,141	23,398	127,250	308,638
1923	1,759,466	36,622	336,369	652,995
1924	1,184,575	- - - -	219,870	438,323
1925	1,160,363	- - - -	249,972	386,418
1926	1,516,686	- - - -	318,407	526,974

Source: The Production of Iron and Steel and Their Products. 1919,1930. Dominion Bureau of Statistics.

Table 5

MATERIALS CHARGED TO BLAST FURNACES
1906-1926 (Short Tons)

Year	Nova Scotia		Ontario	
	Iron Ore	Coke	Iron Ore	Coke
1906	706,441	462,672	498,032	304,676
1907	751,235	521,068	523,372	327,082
1908	722,916	492,076	515,820	325,670
1909	708,029	412,016	795,434	507,255
1910	695,117	491,281	825,201	476,838
1911	779,282	543,933	934,764	577,388
1912	876,572	609,183	1,214,181	656,815
1913	1,015,623	710,260	1,228,970	706,888
1914	458,362	330,269	1,047,968	590,902
1915	840,394	578,743	916,399	486,022
1916	914,194	712,715	1,271,677	645,488
1917	874,134	634,962	1,302,162	723,657
1918	754,622	561,135	1,489,118	861,522
1919	519,722	372,203	1,232,863	689,548
1920	n.a.*	415,742	n.a.	788,795
1921	n.a.	244,830	n.a.	526,963
1922	n.a.	127,250	n.a.	308,558
1923	n.a.	336,369	n.a.	652,995
1924	n.a.	219,870	n.a.	438,323
1925	n.a.	249,972	n.a.	386,418
1926	n.a.	318,407	n.a.	526,974

*n.a.-not available

Source: Calculated from Table 4.

> Canadian ores 293,305 tons, in 1915. All the fuel used, with the exception of a small quantity of charcoal was imported either as coke, or as coal . . .[1]

With this in mind, it is possible to interpret the various columns of Table 4. The national figures on coke produced from domestic coal are Nova Scotia's fuel inputs, since Ontario utilized no domestic coal in its production of coke. Ontario's fuel input becomes the national column of coke either made from imported coal or imported from the United States. An assumption had to be made in regard to the value of coke used in Ontario. The producers of this province produced coke in their own ovens from imported coal in addition to importing coke directly. The problem lies in the fact that the prices of the coke produced and imported differed, so that the combination has to be known in order to calculate the total cost of coke charged to Ontario furnaces. Because this combination is unknown it was assumed that the Ontario producers used their entire production of coke in the furnaces and that any discrepancy between the total coke consumed and the domestic production was made up by imported coke.

The national figures of domestic iron ore used are attributed to the iron ore input of Ontario producers since Nova Scotia producers relied almost exclusively on the Wabana

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[1]Department of Mines, Mines Branch, <u>The Production of Iron and Steel in Canada</u> (Ottawa: King's Printer, 1915), p. 15.

Mine for iron ore. For the division of the national imported iron ore figure into its two component parts, Newfoundland and Mesabi Range imports, observations made by the Department of Mines on the quantity imported by Ontario, such as found in the preceding quotation, were relied upon. This information was dropped from the reports of the Department after 1919 and no feasible alternate method was found to obtain satisfactory iron ore input figures by provinces after this date.

In order to complete the cost calculation, information other than just quantities of the inputs used must be obtained. The prices of the inputs and the degree of substitutibility of the factors of production must also be known. The elasticity of substitution is extremely important for it shows to what extent changes in prices of the inputs are actually transferred to the cost function of the industry.

For the pig iron industry, since rigid proportions of materials are required for the production of a ton of product, the type of function that would best characterize the industry is the Leontief production function. No substitution of coke for iron ore is possible in the production process if the same amount of output is to be produced. Thus changes in prices or qualities are transferred directly to the cost function with no substitution possible for the more expensive or less efficient factor. By qualities is meant the tons of output produced

per ton of input.

The price of coke produced by the provinces was obtained for Nova Scotia and Ontario from statistics on coal and coke production in Canada kept by the Department of Mines and is presented in Table 6. Prices of imported coke for Ontario's producers are derived from the same source. To obtain Ontario's total cost of coke charged to blast furnaces, a combination of these two prices and the assumption made concerning the division of Ontario's coke consumption between imported and domestically produced was made. For Nova Scotia, with only one domestic supply, the cost calculation is relatively easy.

The most inadequate part of the reconstruction is that which deals with the price of iron ore charged to the blast furnaces. Nova Scotia's and Ontario's prices can be derived from customs records. For Nova Scotia's imports from Wabana the prices are only available after 1911. To derive the rest of the observations, an assumption was made that Sydney producers would pay $1.00 a ton. This is a reasonable assumption in light of the prices paid according to later customs records.

For the price of iron ore for Ontario, export price figures were used based on the United States customs records, as reported in various issues of The Production of Iron and Steel in Canada. These figures are presented in Table 7. A further difficulty arose in regard to the quantities of

Table 6

AVERAGE VALUE OF COKE ($per Ton) 1906-1926

Year	Nova Scotia	Ontario
1906	$3.23	$2.73
1907	3.22	3.53
1908	3.27	2.64
1909	3.26	2.27
1910	3.25	2.74
1911	3.26	3.35
1912	2.94	3.76
1913	3.26	4.08
1914	3.26	3.33
1915	3.25	3.15
1916	4.00	4.03
1917	5.00	6.18
1918	10.12	7.77
1919	10.28	10.65
1920	10.16	11.21
1921	8.51	11.74
1922	4.80	8.56
1923	8.70	8.60
1924	6.25	7.43
1925	5.43	7.18
1926	4.90	7.17

Sources: Calculated from the Annual Report on Mineral Production in Canada 1906-1910, 1922, 1925, 1928 and The Production of Coal and Coke in Canada 1911, 1913, 1915, 1917, Department of Mines, Mines Branch.

Table 7

AVERAGE VALUE OF ORE CHARGED ($per Ton) 1906-1926

Year	Nova Scotia	Ontario
1906	$1.00*	$2.40
1907	1.00	2.45
1908	1.00	2.56
1909	1.00	2.70
1910	1.00	2.61
1911	1.00	2.97
1912	1.00	2.95
1913	1.00	2.63
1914	1.00	2.88
1915	.96	2.55
1916	.98	2.68
1917	1.04	3.19
1918	1.05	3.65
1919	.87	3.59
1920	1.40	3.74
1921	1.33	3.66
1922	1.00	3.38
1923	1.00	2.94
1924	1.00	3.36
1925	1.00	2.62
1926	1.01	2.32

*Assumed values for Nova Scotia 1906-1911.

Sources: Calculated from _The Production of Iron and Steel in Canada, 1915, 1922, 1925_, Department of Mines, Mines Branch, and _The Trade of Canada 1927-30_, Department of Trade and Commerce.

iron ore charged in 1907-1909, figures for which are not directly available. In order to fill the gap it was necessary to interpolate using the inverse of the average efficiency measure over the period multiplied by the total pig iron production in each of the years. In this way the quantity of ore charged can be generated for each province in the three years 1907-1909. With respect to the value and quantities of pig iron produced by provinces a complete time series was directly available.

As far as can be determined the prices of these inputs are the prices paid at the blast furnace, including transportation costs. Since coke was produced domestically by the producers in their own coke ovens, no transportation costs were involved. The Department of Mines gave values of imported iron ore which were based on reports received from the blast furnace operators of the prices paid for iron ore at the furnace. The only possible price that might not include transportation costs is the price of imported coke. However, if the values were reported as the value at the border, further transportation costs to Ontario furnaces on the Great Lakes could hardly be large enough to make any significant difference in the cost calculations.

The Cost of Coke

The major results of the cost of coke calculations are presented in Table 8. The results were arrived at in

Table 8

COKE STATISTICS 1906-1926

	Nova Scotia		Ontario	
Year	Efficiency*	Processing Burden %	Efficiency*	Processing Burden %
1906	0.6808	43.45	0.9044	19.17
1907	0.7032	39.83	0.8421	25.20
1908	0.7166	45.26	0.8336	19.68
1909	0.8382	37.13	0.8023	19.26
1910	0.7130	37.98	0.9379	18.89
1911	0.7174	37.86	0.9120	27.53
1912	0.6976	28.09	0.8976	30.08
1913	0.6759	32.15	0.9179	30.55
1914	0.6874	36.47	0.9411	27.47
1915	0.7261	34.42	1.0153	27.86
1916	0.6595	40.43	1.0832	25.94
1917	0.7435	30.56	0.9460	31.96
1918	0.7411	54.33	0.8678	31.22
1919	0.7659	53.67	0.9063	42.97
1920	0.7997	54.94	0.9496	39.74
1921	0.6923	47.27	0.9402	48.02
1922	1.0629	19.45	0.9517	40.67
1923	0.9244	54.59	1.0328	35.09
1924	0.8053	35.76	0.9490	34.18
1925	0.9041	30.83	1.0694	34.50
1926	0.8802	25.30	1.0777	36.00

*Efficiency is defined as the total product per ton of input.

the following manner; from the price of coke per ton and the quantities of coke charged to the furnace, the total cost of coke charged for Nova Scotia and Ontario is obtained. To obtain a comparative cost figure for the Nova Scotia and Ontario producers, the processing burden with respect to coke is calculated. It is defined as the percentage the total cost of coke makes up of the total value of production, or more simply the cost of coke per dollar of total cost of production. This result is also presented graphically in Figure 2.

Figure 2 demonstrates that Ontario has an advantage in 1906 paying out less for coke for every dollar of output. From the data on the price of coke charged to the furnace and the efficiency of the coke[2]--the total output per ton of coke--it is not difficult to pinpoint the cause of this advantage, for while Ontario's coke is more expensive it is also more efficient. This efficiency more than compensates for the higher price of coke.

The Cost of Iron Ore

The major results of the iron ore cost calculations are presented in Table 9. The results were arrived at in the following manner: from the price of iron ore per ton and the quantities of iron ore charged to the furnaces, the total cost of iron ore for Nova Scotia and Ontario is

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[2]See Figure 3 for an illustration of the trend of efficiency.

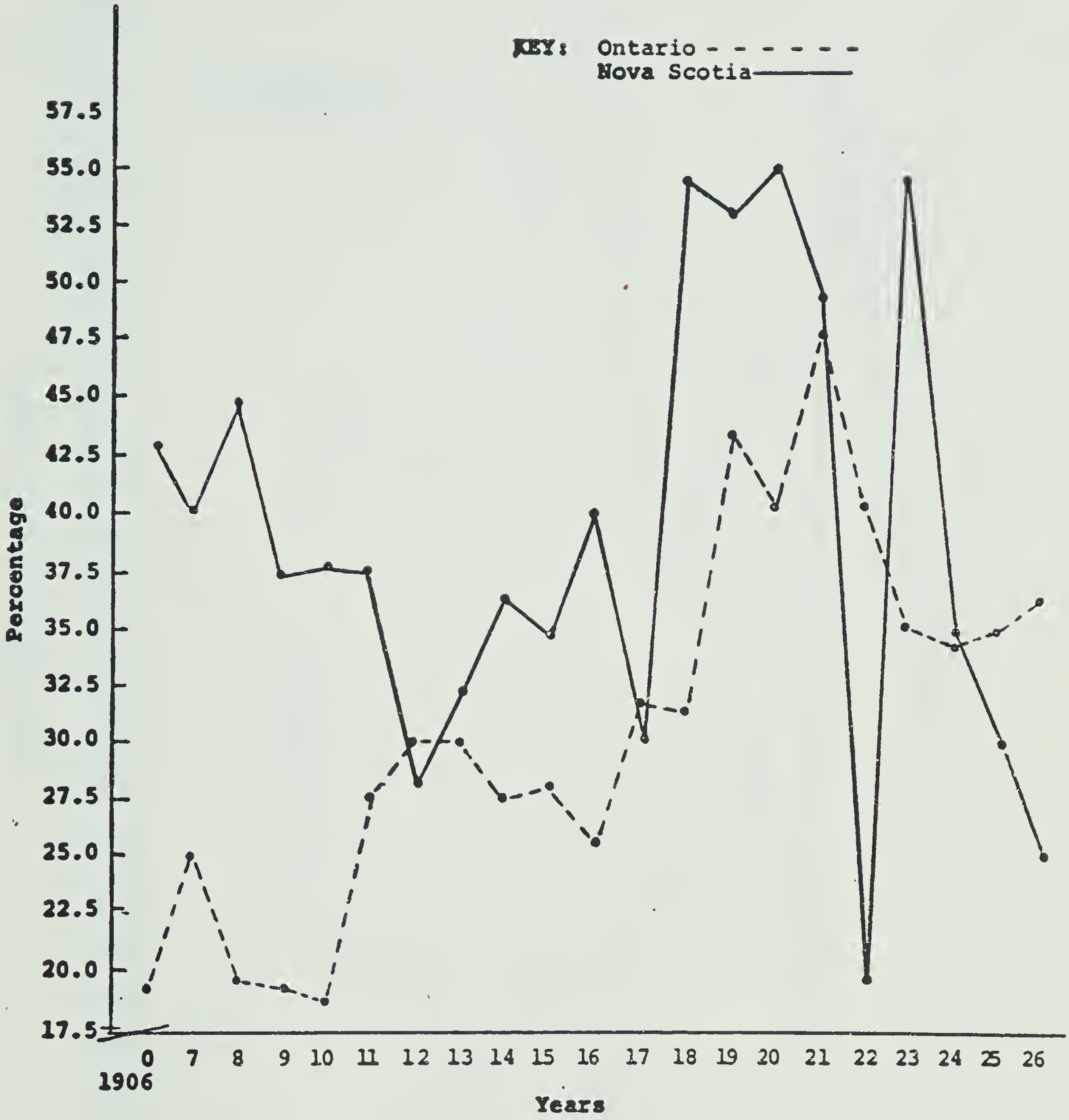

Figure 2 - Processing Burden of Coke 1906-1926.

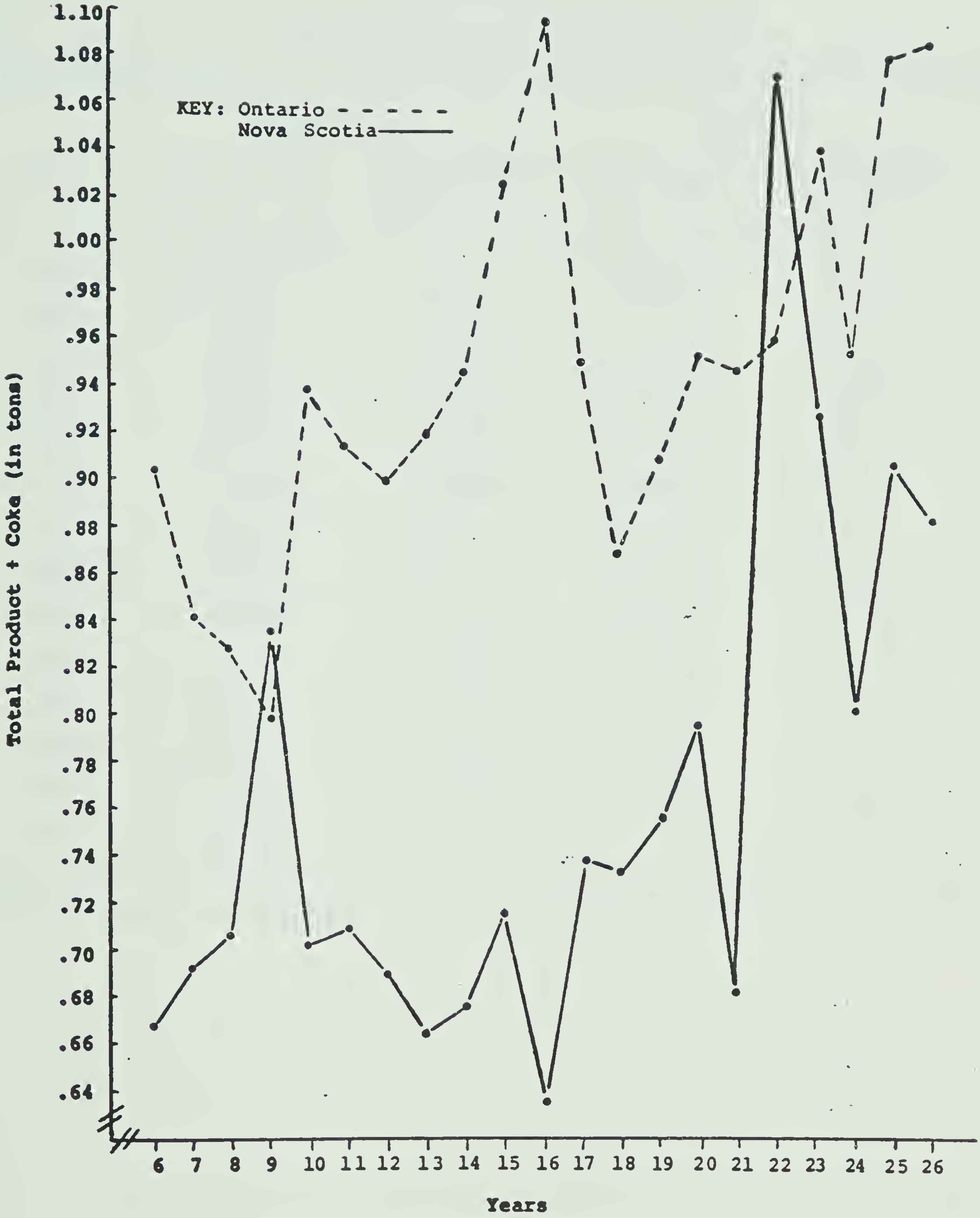

Figure 3 - Coke Efficiency 1906-1926.

Table 9

IRON ORE STATISTICS 1906-1919

	Nova Scotia		Ontario	
Year	Efficiency*	Processing Burden %	Efficiency*	Processing Burden %
1906	0.5374	20.54	0.5532	25.97
1907	0.4878	16.81	0.5263	28.78
1908	0.4878	20.33	0.5263	31.52
1909	0.4878	21.75	0.5263	35.82
1910	0.4911	16.96	0.5420	30.94
1911	0.5007	16.64	0.5633	36.69
1912	0.4683	14.23	0.4855	43.79
1913	0.4633	14.38	0.5280	34.66
1914	0.4953	15.52	0.5306	42.78
1915	0.5000	14.76	0.5385	39.54
1916	0.5141	12.70	0.5498	35.14
1917	0.5401	8.75	0.5257	29.85
1918	0.5510	7.58	0.5020	25.51
1919	0.5485	6.33	0.5069	25.90

*Efficiency is defined as the total product per ton of input.

obtained. To obtain a comparative cost figure for the Nova Scotia and Ontario producers the processing burden with respect to iron ore is calculated. It is defined as that percentage which iron ore costs make up of the total value of production, or the cost of iron ore per dollar of total cost of production. This result is illustrated graphically in Figure 4. This figure demonstrates that Nova Scotia has the advantage with respect to iron ore costs in 1906 since it pays out less for iron ore for every dollar of output than Ontario. Moreover, as the efficiency of the iron ore[3] is almost the same, Nova Scotia's iron ore cost advantage can be attributed to the cheap price of its supply of iron ore.

Total Material Cost

Both of the inputs are combined and a total material processing burden is calculated, defined as the percentage the cost of materials, iron ore and coke, make up of the total value of production, so that the material cost comparisons can be made. The results are illustrated graphically in Figure 6. In 1906, the earliest year for which it is possible to obtain data, Ontario has an advantage paying less for its material per dollar of output than Nova Scotia. Since Nova Scotia held the cost advantage with respect to iron ore, Ontario's advantage with respect to

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[3]See Figure 5 for an illustration of the trend of efficiency.

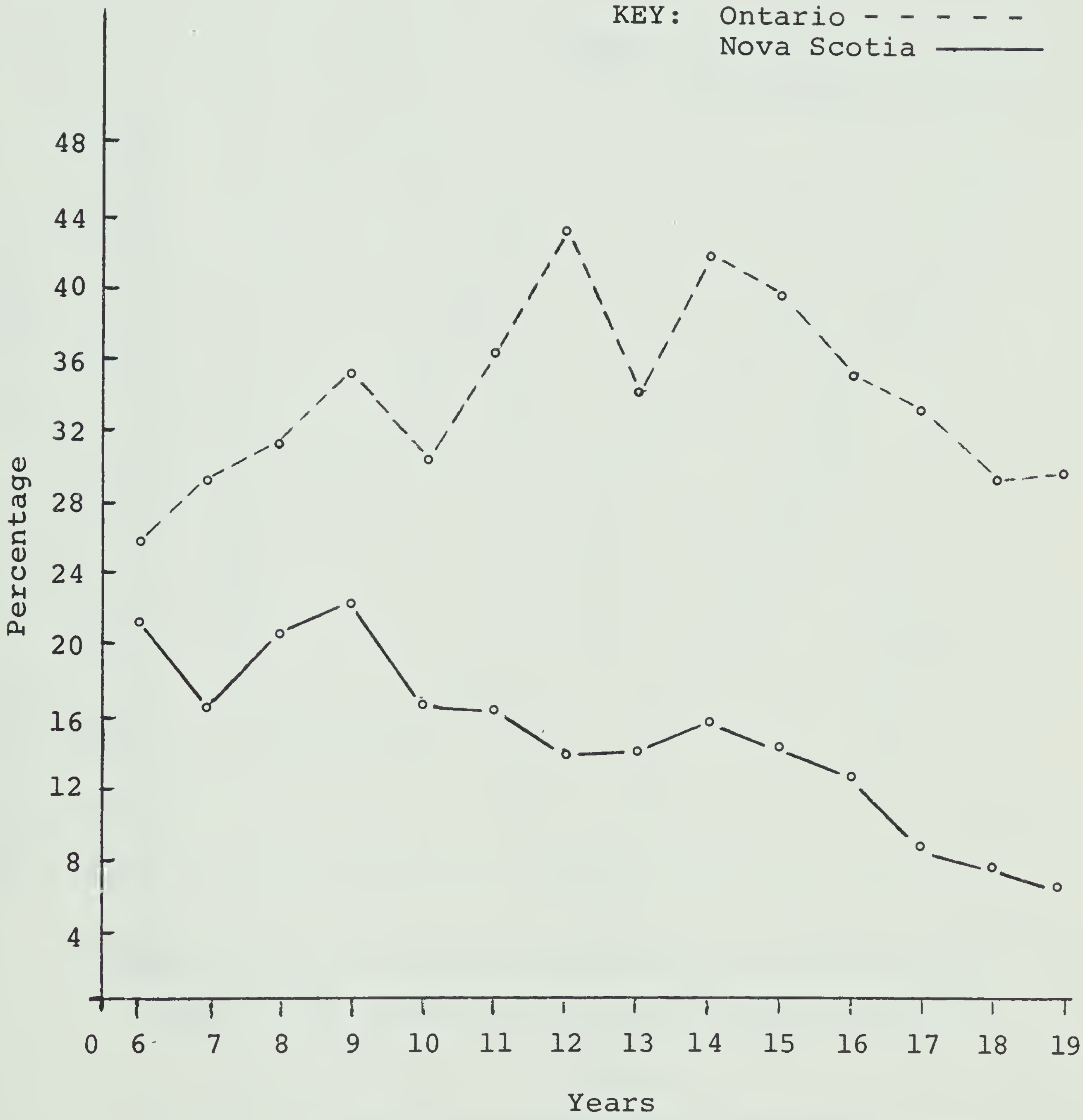

Figure 4 - Processing Burden of Iron Ore 1906-1919.

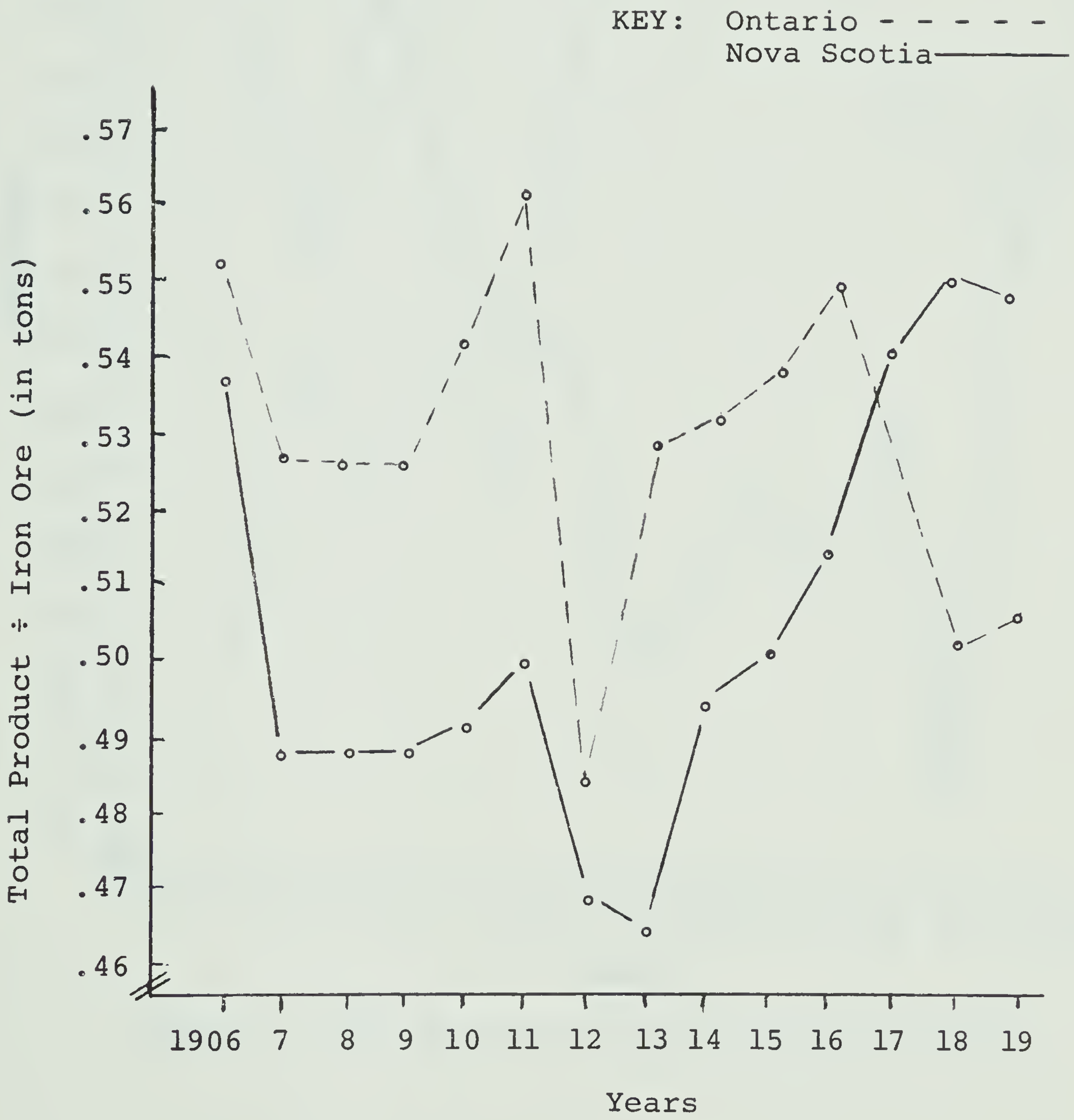

Figure 5 - Iron Ore Efficiency 1906-1919.

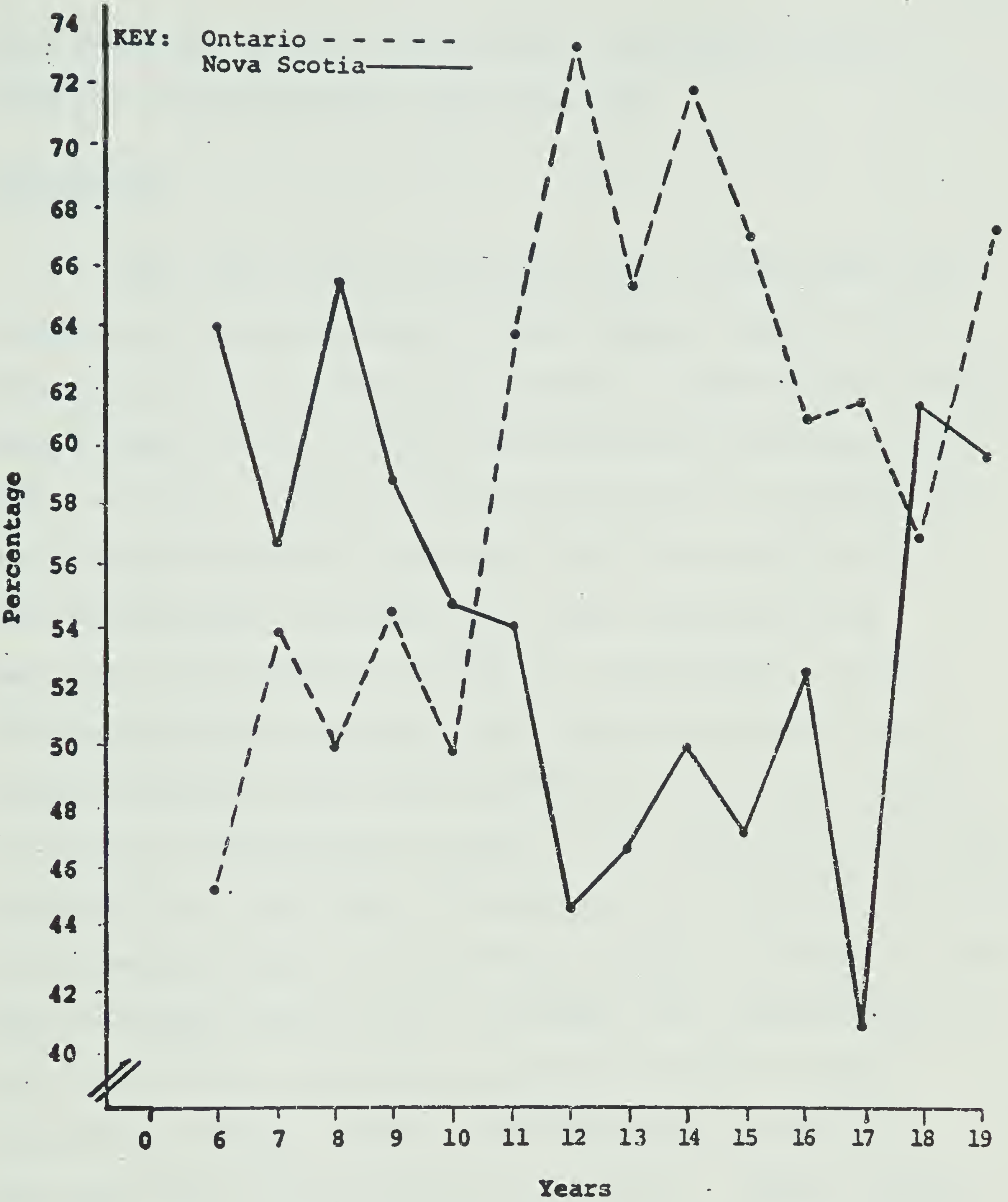

Figure 6 - Total Materials Processing Burden 1906-1919.

coke outweighs the Nova Scotia cost advantage to give Ontario a total material cost advantage.

Conclusions

The first major conclusion that is drawn from the statistical work presented in this chapter concerns the validity of Isard's thesis for Canada. Since Canada did not have a long history of pig iron production utilizing coke prior to 1896, it is not directly possible to compare coke efficiency before this time with coke efficiency in the 1896-1926 period. Assuming that coke technology was available from the United States, a continuation of the efficiency trends observed there could be expected for an Ontario location since the producers used the same sources of coal, the Pennsylvania fields. This trend had led to the decline of the coal site, Pittsburgh, as a producer in favour of the market sites, Cleveland and Chicago. Because of the lack of demand for pig iron in Canada, the establishment of the first Ontario location was slow to react to these locational changes. These coke efficiency trends are continued later in the period after 1906. Isard's thesis concerning the increasing efficiency of coke and the declining importance of the coal site can be accepted as an explanation for the possibility of an Ontario pig iron producer at this time.

The second major conclusion answers the question of why Ontario was able to produce successfully in relation

to Nova Scotia in 1896. The cost calculations show that Ontario, in 1906, the earliest date for which it is possible to obtain adequate data, had a material processing cost advantage. Since Ontario had this cost advantage, Hamilton as a convenient assembly point for materials appears to be as good a resource site as the Nova Scotia locations. This would dampen the general argument that attributed Ontario's successful location solely to the pull of the market. This conclusion is important for it adds a possible explanation to Ontario's success that has not been fully recognized in the economic history literature.

The cost statistics of this chapter have also revealed trends in the material costs of the producers. During the period Ontario's material costs increased relative to Nova Scotia, yet Ontario's market share relative to Nova Scotia's continued to rise. The factors involved which favoured Ontario in spite of its rising material costs, are discussed in the next chapter.

CHAPTER V

THE REGRESSION RESULTS

This chapter tests several of the main hypotheses concerning long run changes in the locational pattern of the pig iron industry that appear in the economic history literature. The aim is to explain why an increasing share of pig iron was produced in Ontario over the period to 1926. Two types of hypotheses are involved; those relating to cost variables and those relating to historical demand variables.

The Hypotheses

The first type, the cost hypotheses, will seek to explain the changing locational pattern in terms of changes in the cost components. The rationale behind these hypotheses is that any long run changes in these components, either in terms of factor price or quality, will affect the producer's cost position and thus his competitive position in the market. The explicit variables that are incorporated into the regression analysis as explanatory variables are the price of iron ore, the price of coke, the efficiency of coke and the price of labor. It was not feasible to include the efficiency of iron ore because complete time series data does not exist for the period 1906-1926.

The first three variables have been discussed in connection with the cost calculations of Chapter IV. As a

proxy for the cost of labor utilized in the operation of blast furnaces, a historical series on the hourly wage of a laborer in Halifax and in Toronto was used. No measure for the efficiency or productivity of labor is included, since it is assumed that labor is equally productive in the operation of blast furnaces regardless of an Ontario or a Nova Scotia location.

In general, negative relations are expected between the prices of iron ore, coke and labor in a particular location, and the success of a particular location. As these variables increase or decrease in size the producer's cost will increase or decrease, and his position in the market will be adversely or favourably affected. It is expected that a positive relation exists between the efficiency of coke in a particular location and the success of that location since an increase in the efficiency of coke will result in a better competitive position, thus favouring his long run position in the market and vice versa.

The second type, the historical hypotheses, are the more traditional explanations given by economic historians. The first of these concerns the reliance of the various producers upon the railroad as a major customer for iron and steel products and how this reliance affected the locational pattern of the industry. That the Nova Scotia producers were more dependent on the railway for business than their Ontario competitors has been argued by

Kilbourn.[1] As the railroad construction booms phased out, Nova Scotia's market position was damaged relative to Ontario's. Thus Ontario's relative gain in the market for pig iron production is to be explained, in part, by a less excessive dependence on the railroad.

The second of these hypotheses concerns the effect the wheat boom and the opening of the market in the west for iron and steel products had on the respective producers. Economic historians suggest that this new market had a positive effect on the producers of Ontario and a negative effect on the Nova Scotia producers since the former, being geographically closer to the West, were better able to supply the farm population with iron and steel products including agricultural machinery.[2] Thus Ontario's relative success is explained by its better market location with regard to the West than its Nova Scotia competitors. Because railroad expansion occurred in the West at this time there may be an overlap in the two hypotheses. A basic difference in the aim of the hypotheses remains, however, that justifies the use of both hypotheses. In the first case, interest lies in testing the relative reliance of the producers on a particular customer, the railroad; in the second case interest lies in testing the reliance of the producer on

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[1] Kilbourn, pp. 125-126.

[2] For example see Canada, Royal Commission, <u>Report on Dominion-Provincial Relations</u> (Ottawa: King's Printer, 1940), Book I, pp. 66-79.

another customer, the farmer. It is clear that the anticipated influences on the producers are not the same in the two hypotheses, although they may be difficult to disentangle empirically.

The third hypothesis concerns the effect the local market for consumer goods had on the locational pattern of the pig iron industry. Economic historians have suggested that the large and growing population centers and the markets for consumer goods favoured Ontario, and that the Nova Scotia and Maritime market was generally too small to support industrial concerns. Ontario's relative gain in the pig iron industry was partly a pure market phenomenon as the location of pig iron producers was influenced by the pull of the market. To obtain an idea how local markets were changing in size and how these changes affected the locational pattern of the pig iron industry, provincial population figures should be used. Since these figures are not available on a yearly basis, total Canadian population was used with the knowledge from census data that Ontario's population was growing faster than the Maritime's. It is expected that this proxy for the local markets will have a positive effect on Ontario's pig iron market position and a negative effect on Nova Scotia's since the local market of Ontario was growing relative to that of the Maritimes. This hypothesis is different than the effect of the West hypothesis, as it is concerned with changes in the local Ontario market relative to the Maritime market.

The fourth hypothesis concerns the effect the changing distribution of industrial activity and capital goods industry in Canada had on the pig iron industry, a supplier of a basic input to the capital goods manufacturing concerns. Economic historians have argued that the growing industrialization and capital goods production of Canada, which was concentrated in Central Canada, would obviously benefit the Ontario producers who were located right in the center of this growing industrial heartland, while Nova Scotia producers were effectively isolated by distance. At this time, moreover, the exploitation of the Canadian Shield opened up a new market for heavy equipment, machinery and mining equipment and other capital goods. Ontario's gain in pig iron production then, in part, is explained by being in a better geographical position to supply materials to the industrial heartland and equipment to the Canadian shield. As a proxy for the effect of the growing industrial heartland, the net annual flow in value terms of machinery and equipment which incorporates agricultural, industrial, electrical and mining equipment, railway stock, land vehicles, and ships and office, store and professional equipment will be used. Some duplication of the effects of other hypotheses, especially with regard to the West and the railroad, is unavoidable since the only available capital series includes agricultural machinery and railway stock.

Because this definition includes several components of the capital goods used for consumer goods production

and their location may be consumer orientated, it might be argued that this hypothesis is not different from the consumer market hypothesis. But because this definition also includes components of capital goods not utilized in consumer goods production such as mining equipment and therefore not tied to consumer market location, this hypothesis is logically different from the consumer market hypothesis. Moreover, this definition is a proxy for the influence of capital goods production and the exploitation of the Canadian Shield on the locational pattern of the pig iron industry.

The last hypothesis concerns the effect the First World War had on the locational trend of the industry. Economic historians have tended to believe that the Maritimes gained at such times at the expense of the Ontario producers. It is argued that during the war Nova Scotia temporarily regained her mid-nineteenth century position as the industrial heartland of Canada, supplying the raw materials and munitions for the war effort. If this is correct an improvement in the market position of Nova Scotia relative to Ontario, for these few years with an equal decline thereafter, should be observed.

The Dependent Variable

The ideal variable to use to reflect the long run shifts in the locational pattern in the industry would be installed capacity. The theory of investment suggests

that a producer, in the long run, would react to changes in the types of variables that are to be examined here by adding to or scrapping his plant, depending on the trends of the variables relative to those of his main competitors. For example, a long run relative decline in the cost of production caused by a decline in the price of an input or an increase in its quality would induce the entrepreneur to expand his productive capacity as his present capacity is pressed by expanding business. Thus the level of capacity properly represents the long run changes in the locational pattern of an industry, and the most theoretically correct way to proceed would be to estimate some type of investment function in relation to the long run variables.

However, for the iron and steel industry it is difficult to obtain a proper measure for capacity that is defined consistently throughout the period nor do figures on capital expenditures exist for this period. In light of this deficiency it was necessary to utilize another measure that would represent capacity. For this purpose the market share of the producer was chosen, being defined as the percentage the producer's production of pig iron in tons is of total Canadian production. The validity of the use of this representation is justified by the use of a simple investment model. It is postulated that capacity decisions are a function of the producer's expected market share. This expectation will in turn be a function of past and present market shares in some type of distributed lag

function, with the most weight being put on the most recent experience. The data available hardly justify formulating a rigorous distributed lag model, so that only the present market share was used. This will understate the significance of the independent variable to the extent a lag is at all significant; the repercussions of this on the model will be examined later. In this way, through a chain of causal relations, market shares can be used as a representation of capacity in a regression analysis.

The Regression Results

The hypotheses can be represented by the following function:

MSR = f(POR, PCR, BR,WAGER, RRR, ACRE, POP, PROD, TIME)

where the following definitions were used for the variables:

MSR--the market shares ratio--the ratio of the market share of Nova Scotia to the market share of Ontario (Table 1).

POR--the price of iron ore ratio--the ratio of the price of iron ore for Nova Scotia to the price of iron ore for Ontario (Table 7).

PCR--the price of coke ratio--the ratio of the price of coke for Nova Scotia to the price of coke for Ontario (Table 6).

BR --the inefficiency of coke ratio--the ratio of the inefficiency of coke for Nova Scotia to the

inefficiency of coke for Ontario where inefficiency measures the inverse of efficiency, i.e., coke used per ton of output (Table 8).

WAGER--the wage rate ratio--the ratio of the hourly wage rate of laborers in Nova Scotia to the hourly wage rate of laborers in Ontario (M. C. Urquhart, (ed.) Historical Statistics of Canada, (Toronto: The Macmillan Company of Canada Ltd., 1965), p. 86).

RRR--the net yearly increase in single track railway mileage (Urquhart, op. cit., p. 532).

ACRE--number of new homesteads and land grants in the Prairie Provinces (Urquhart, op. cit., pp. 320-321).

POP--the population in Canada (Urquhart, op. cit., p. 14).

PROD--net annual flow of machinery and equipment (K. Buckley, Capital Formation in Canada 1896-1930 (Toronto: University of Toronto Press, 1955), p. 130).

A linear functional form was utilized and a constant term included. The variables are specified in ratio terms so that the effects of relative changes in the cost variables could be observed on the relative shares of the producers.

The results of the regression using ordinary least squares as an estimation technique are presented in Table 10. Regression 2 incorporates a dummy variable, DUMM, equal to one in the war years and zero in every other.

The fit of both equations is quite good: the explanatory variables in the first explain over 90 per cent of the

Table 10

THE REGRESSION RESULTS

Variables	Regression 1 Coefficient	t Values	Regression 2 Coefficient	t Value
C	6.68	3.68	6.73	3.46
POR	1.69	2.29	1.63	1.83
PCR	-0.15	-0.98	-0.14	- .71
BR	-0.24	-1.45	-0.23	-1.18
WAGER	0.37	0.89	0.35	.78
RRR	0.00005	1.34	0.00005	1.13
ACRE	-0.00001	-3.15	-0.00001	-2.67
POP	-0.0009	-3.00	-0.0009	-2.84
PROD	-0.001	-2.26	-0.001	-2.14
TIME	0.10	1.98	0.10	1.88
DUMM	- - -	- - -	-0.14	- .14
R^2/D.W.	R^2=.9424	D.W.=2.38	R^2=.9425	D.W.=2.41

variation of the dependent variable, the explanatory variables in the second explain over 90 per cent of the variation of the dependent variable.

The results of the tests of hypotheses from regression 1 are extremely interesting and to some extent unexpected. For the first variable POR, the price of iron ore ratio, the variable itself is statistically significant[3] and the coefficient's sign is positive. The interpretation of this is that as the price of iron ore goes up for the Nova Scotia producer relative to Ontario so does the Nova Scotia market share relative to Ontario. Obviously this has no proper economic meaning and the significance is just spurious. There is no economic reason to believe that as the price of iron ore goes up relative to the other competitor so will the relative market share of that producer. The anticipated sign of this variable is negative.

The second variable PCR, the price of coke ratio, behaves properly in an economic sense in that its sign is negative, meaning that as the price goes up relative to the other competitors one's cost position will deteriorate and the relative market share will decline. The variable lacks strict statistical significance as its t score is well below the -2.26 needed to reject the null hypothesis that its

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[3]At n-k degrees of freedom where n=20 the number of observations and k the number of explanatory variables the critical value of the t score at the 95% confidence level is 2.26.

coefficient is not significantly different from zero.

The third variable BR, the inefficiency of coke ratio, has the proper economic sign; as a competitor's relative inefficiency goes up, his relative market share declines because of higher costs. It too lacks strict statistical significance since its t value of -1.45 is less than the required -2.26 value.

The fourth variable WAGER exhibits a positive sign and would be interpreted as follows; an increase in the relative wage cost causes an increase in the producer's relative market share. This, as in the case of POR, is not a meaningful economic result. The t value of this variable again lies below the significant score of 2.26 being 0.89 so that the null hypothesis that the coefficient is not significantly different from zero is not rejected.

The first of the historical variables, designed to test the influence of the railway as it may have differentially affected the producers, is RRR the net yearly increase in single track railway mileage. The coefficient of this variable is positive as expected. Thus as this variable increases or decreases over time so does Nova Scotia's relative market share. Although the variable has the right sign, it does not meet the strict statistical mark of 2.26, its t value being 1.34.

The second variable designed to test the effects of the opening and expansion of the West is ACRE, the number

of new homesteads and land grants in the Prairie Provinces. This variable has the expected negative sign. This has the interpretation that as the West expanded Nova Scotia's relative market share declined. This variable does meet the rigid statistical standards of the t score -2.26 having a t value of -3.15. The null hypothesis is therefore rejected and the hypothesis concerning the West and its market pull is confirmed.

The third variable, designed to test the hypothesis concerning the changing local consumer market of Nova Scotia and Ontario, is POP the population of Canada. This variable has the expected negative sign. This is interpreted in the following manner; as the population of Canada expands, it can be observed that Ontario's population grows in a larger proportion than Nova Scotia's, meaning Ontario's local consumer market expands relative to Nova Scotia's or the Maritimes' market. Thus the Ontario producers achieve a larger market share at the expense of Nova Scotia, since they are located at the heart of the consumer market. Since this variable has a t score of -3.00, it confirms the hypothesis that the consumer market had a negative effect on Nova Scotia. For Ontario, the traditional view of the pull of the market on the pig iron industry is confirmed.

The fourth variable, which is designed to test the hypothesis concerning Canada's changing industrial heartland and the capital goods market, is PROD. This variable

has the expected negative sign. That is, as industrialization procedes as reflected by the growth of heavy industry and capital goods manufacturing Nova Scotia is unable to reap the benefits of this as a supplier of the basic input, iron and steel, because of location outside of the industrial heartland of Canada. In part, this growth of capital goods production occurred as a direct response to the opening of the Canadian Shield. Ontario attains the benefits in terms of an increasing market share, because of a more favourable location.

The fifth variable TIME is a trend variable included to capture any variables that the model may have left out. In this equation TIME has a positive coefficient and is almost significant, suggesting some variables may have been left out that tend to make Nova Scotia's market share relative to Ontario rise over time. At this point, there are several possible explanations for this phenomenon.

The most standard explanation of a time trend would be technical change favouring Nova Scotia over Ontario. TIME would not be picking this up here for technical change would be manifest in the efficiency variables. Therefore, TIME can not be significant because of any technical change occurring. There is also no evidence that superior management or better entrepreneurship was available to and favoured Nova Scotia relative to Ontario. Another possible explanation is that Nova Scotia's rising efficiency of iron ore

relative to Ontario may have benefited the producers by reducing their costs and enhancing their cost position. However, as the difference in the efficiency between the ores was so small, it could hardly account for the significance TIME experiences. None of the more obvious explanations seem relevant so this significance is left as a puzzle.

The possible effects of the war years can be easily incorporated into the equation by means of a dummy variable. The hypothesis to be tested suggests that the war caused a shift of Canada's industrial heartland back to the Maritimes from Central Canada. The results are presented in Table 10 as the results of regression 2. For DUMM, the dummy variable, a negative coefficient was estimated with a t score of -.14; regardless of its significance it is the wrong sign. Because of the lack of significance, the conclusion that the war years benefited the iron and steel producers of Nova Scotia can not be accepted.

The objection to the specification qualifies the interpretation of the variables. Since the distributed lag structure could not be utilized, the significance of the variables may be underestimated if the complete response occurred only after a number of years. With this in mind, a reinterpretation of the insignificance of some of the variables is in order. The dependent variable exhibits a downward trend over time so the insignificance of an

explanatory variable could be justified in long run only if it did not exhibit a similar trend.

For example, the long run PCR, the price of coke ratio, experiences the trend shown by the following simple regression of PCR and TIME.

$$PCR = 1.17 - .019\ TIME \qquad R^2 = .2957$$
$$(t = -2.75) \qquad D.W. = 1.749$$

As the slope is .019, as compared to the intercept 1.17, this function exhibits a perceptible downward trend. As this trend exists, it is not possible to argue that the insignificance of the variable is due to the fact that there is no long run trend. It is possible that a significant relation could exist if the relationship were properly represented. The use of the short run market share variable may be causing specification errors resulting in the underestimation of the significance of this variable.

A similar test may be applied to BR, the inefficiency of coke ratio. Over time, however, this variable does not exhibit a long run trend. In the simple regression of BR against TIME the following results were observed:

$$BR = 1.29 - 0.004\ TIME \qquad R^2 = .0305$$
$$(t = -.75) \qquad D.W. = 1.45$$

Since the null hypothesis that the coefficient of TIME is not significantly different from zero is not rejected, the variable BR exhibits no trend. The insignificance of this variable in the original equation is supported.

The proxy for the influence of the railroad RRR might also be reinterpreted. Over the long run RRR does not exhibit a trend;

$$RRR = 1527 - 50.9\ TIME \qquad R^2 = .0918$$
$$(t = 1.34) \qquad D.W. = 1.01$$

Since the null hypothesis that the coefficient of TIME is not significantly different from zero is not rejected, the variable RRR does not exhibit a long run trend. Thus the insignificance of this variable in the original equation regressed against the market share ratio is supported.

The two variables that exhibit the opposite signs to what economic theory would predict POR and WAGER, can either be neglected because of spurious correlation, or a reinterpretation of the causal relations involved can be made. If these two variables were made dependent variables with the market share ratio an independent variable, the positive relationship between these variables might be explained. As the market share of a producer went up the prices of his inputs, in this case iron ore and labor, might follow in response to the demands of the expanding producer for more inputs. This argument is plausible only if the supply of inputs is relatively inelastic. Generally, as the Canadian producers only formed a small part of the market for North American pig iron inputs, the elesticities of supply they would face would be infinitely elastic--that is increases in their demands would have little or no effect on supply prices.

Conclusions

In general, the conclusions of the tests of hypotheses performed in the regression analysis are somewhat limited by the inability to properly specify the model. With this qualification aside, several conclusions can be usefully drawn.

With respect to the cost hypotheses only the price of coke ratio might be capable of providing an explanation of the long run locational success of the Ontario producer. This is only possible if the lagged response was especially evident here since the t value has to increase by a large amount to reach the critical value. In the case of the price of ore ratio and the wage rate ratio wrong signs were obtained so that these variables can not be used to explain Ontario's success. In the case of the inefficiency of coke ratio, its lack of a long run trend does not allow the possibility of its low t value being increased to the critical value.

With respect to the historical hypotheses, the influence of the railway can not be made significant by appealing to specification error since the variable does not exhibit a long run trend.

The three variables that can be accepted without qualification are the role of the local consumer market as represented by Canada's population, the role of the capital goods market and industrialization, and the role

of the West. These three variables can be used to explain why Ontario achieved an increasing share of the pig iron market.

In general, the cost hypotheses are not capable of providing a strong explanation for the increasing share of Ontario. Economic historians have been more successful in providing market reasons for this development. The impact of the West, the pull of the consumer market as it grew in Ontario, and ever increasing concentration of heavy industry and capital goods production in Ontario are all hypotheses supported by economic historians and verified in this thesis. The one historical hypothesis this thesis does not find empirical support for is the role of the railway. Perhaps the contribution of this consumer of iron and steel products was not as important to the success or failure of the Nova Scotia producers as economic historians have thought.

CHAPTER VI

CONCLUSION

This thesis has sought to analyze the locational trends of the pig iron industry, beginning with the appearance of an Ontario producer in 1896. Two aspects of the problem have been dealt with; the explanation for the appearance and the initial successful production of Ontario in 1896 and the explanation of the success of Ontario in obtaining an increasing share of the pig iron market.

In general, Isard's thesis has been used to explain the possible appearance of a pig iron producer in Ontario, a market orientated location, late in the nineteenth century. The cost analysis showed that in 1906, the earliest date for which it is possible to obtain data, Ontario had a material processing cost advantage based on more efficient coke and was able to compete successfully with the Nova Scotia producers. The analysis also showed that Ontario lost this advantage, but was still able to expand its share of the pig iron market.

The regression analysis in the thesis tested several possible hypotheses to explain this trend. The hypotheses have been put forth in the economic history literature but have not been subject to rigorous testing. Of these historical hypotheses, three can be used to explain the

increasing share of the Ontario producers; the pull of the local consumer market, the pull of the industrial heartland and the capital goods market, and the opening of the West. In the face of these market pulls, the Nova Scotia producers did not have enough of a material cost advantage to overcome the barrier of transportation costs that were set up when the Ontario producers located at or near these respective markets.

Economic historians, then, have been correct in attributing to the role of the market the major explanation of the changing locational pattern of the pig iron industry. What has not been obvious is the relative magnitude of the pull of the market. So strong was this pull, that material cost disadvantages for Ontario later in the period were overridden so that Ontario became the major producer even in the light of more expensive processing costs.

This study of the changing locational pattern of the pig iron industry also implies something concerning the general failure of the Maritimes to expand industrially at the same rate as Ontario and to achieve the desired aims of their Confederation agreement. From the experience of the iron and steel industry both market and cost factors are involved in the failure of the Maritimes to acquire successful large scale industry. Moreover, as this industry was one that economic historians and Maritimers expected would achieve large scale national success for the Maritimes

as the Central Canadian market was opened up, its failure was demoralizing to the citizens of the Maritimes and weakened the bonds between regions created by Confederation. Their hopes were shattered by the long term reorientation of the iron and steel industry which made market sites possible locations for pig iron producers and reduced the importance of their resource site.

The experience of the iron and steel industry made it clear to the industrial producers of the Maritimes that even when a producer had a material cost advantage, he could still expect problems because of his poor location relative to the main markets of Canada and the strength of the locational pull of the market. Those industries which did not have a material cost advantage had no hope of becoming a major force in the national economy and expanding beyond the borders of their own local markets.

In order to redress this industrial imbalance between Central Canada and the Maritimes, the latter will have to rely on and acquire industrial production whose products have high value and low transportation costs. In these industries the pull of the market is not such a predominant force in the successful location of the firm, and the barriers of transportation costs to the main Canadian markets are more easily overcome. This thesis, in the analysis of a particular industry, has revealed the problems involved in the equitable development of Canada. It can only

be hoped that in the future a more equitable balance may be achieved between regions so that the bonds created by the political union of these regions will remain intact.

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